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Franklin Institute

1884–INTERNATIONAL ELECTRICAL EXHIBITION–1884

REPORT OF EXAMINERS

OF

SECTION VI.

43
8334

CARBONS FOR ARC-LAMPS.

"MERRIHEW PRINT" (J. SPENCER SMITH), 501 CHESTNUT ST., PHILA.

With the compliments of

Persifor Frazer

Philadelphia

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

OF THE

FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS

REPORTS OF THE EXAMINERS

—OF—

SECTION VI.

(SECTION IV-B, OF THE CATALOGUE.)

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CARBONS FOR ARC-LAMPS.

43/8334

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AS A SUPPLEMENT TO THE JOURNAL OF THE FRANKLIN
INSTITUTE, JUNE, 1885.]

PHILADELPHIA:
THE FRANKLIN INSTITUTE
1885.

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t.c. – June 1, 1904 – G.M.C.
J.J.B. Nov. 26/06

EDITING COMMITTEE.

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WILLIAM H. WAHL.

INTERNATIONAL ELECTRICAL EXHIBITION, 1884.

FRANKLIN INSTITUTE, Philadelphia, Pa.

SECTION VI.—CARBONS FOR ARC LAMPS.

To the Board of Managers, Franklin Institute:

GENTLEMEN:—I have the honor to transmit herewith the report of the Examiners of Section VI, on Carbons for Arc Lamps.

Respectfully,

M. B. SNYDER,
Chairman Board of Examiners.

PHILADELPHIA, *May*, 1885.

Prof. M. B. SNYDER,
Chairman of Board of Examiners,
International Electrical Exhibition:

With the permission of Prof. Anthony, Chairman of Group B, I herewith submit separately the report of Section VI, "on Carbons for Arc Lamps." It includes chemical analyses by Dr. Dudley, Prof. Greene and the chairman, a thorough series of specific gravity determinations by A. E. Outerbridge, Jr., a microscopical study of their transverse sections by Dr. Persifor Frazer, and a table of resistances of the carbons, both plain and copper-coated, made by Prof. Wm. A. Anthony.

Respectfully,

SAMUEL P. SADTLER,
Chairman of Section VI.

CHAS. B. DUDLEY,
Secretary of Section VI.

PHILADELPHIA, *May*, 1885.

Section VI had submitted to it for inspection and report the carbons from five exhibitors, viz.:

1. The Brush Electric Company.
2. The Wallace Carbon Company.
3. The Boulton Carbon Company.
4. The Buffalo Carbon Company.
5. The Carré carbons, manufactured by Emile Levy, Paris, and exhibited by Messrs. J. W. Queen & Co.

Of these, the Brush, Wallace, and Boulton companies submitted plain and copper-coated carbons, the Buffalo Company a homogeneous carbon, both plain and copper-coated, and, in addition, a carbon with a core of pure graphite inserted in a sheathing of coke and a carbon with a vitrified coating, while Queen & Co. offered only the uncoated Carré carbons.

It was determined to have chemical, physical and mechanical studies made of these carbons, but the study of the physical characters, resistance, duration of burning in the lamp under different conditions of current, etc., was handed over to the Section on Arc Lights, whose chairman, Prof. William A. Anthony, agreed to take this part of the work.

[A report on the resistance tests came in after this was written, and is appended.]

The chemical and mechanical study was apportioned out among the members of the Section who now present this report, and included determinations of the percentage of carbon, hydrogen and ash, with a qualitative examination of the chief constituents of the latter in the several plain or uncoated samples, the amount of copper on the coated carbons, both absolutely by weight and relatively per unit of length; specific gravity determinations on the uncoated carbons, both with sections of the solid carbons of given length and with the pulverized material; and, lastly, a microscopical study of the structure of the carbon pencils, using for this purpose specially prepared thin cross-sections. The aid of micro-photography has also been availed of in this latter case for the proper illustration of the results.

1. Determination of the percentage composition of the uncoated carbons (carbon, hydrogen and ash).—This was undertaken by Professor Samuel P. Sadtler, and was made to include five samples, viz.: the plain Brush, Wallace and Boulton carbons, the plain solid Buffalo carbon and the Carré carbon. The Buffalo carbon with the graphite core was not analyzed, as the agent of the company said that the sheathing was made exactly of the same materials and by the same methods as the solid carbon exhibited, while the pure graphite core had a sufficiently well-known composition.

The greater part of a single pencil having been reduced to fine powder, the material for analysis was taken from this stock. The determinations were made by the methods of ultimate analysis, using an open tube, three-fourths filled with granular cupric oxide, placing the weighed material in a platinum boat, and conducting over this a slow stream of oxygen. In this way, besides the carbon and hydrogen determinations, the ash could be accurately weighed, and a check established upon the whole.

The results were as follows:

	Brush Carbons.			*Wallace Carbons.*		
	I.	II.	Average.	I.	II.	Average.
Carbon	97·61	97·81	97·71	95·92	......	95·92
Hydrogen	1·32	1·22	1·27	1·15	0·97	1·06
Ash	0·64	0·61	0·63	2·94	2·80	2·87
Occluded air or loss	0·43	0·36	0·39	......		0·15
	100·00	100·00	100·00	100·01		100·00

	Boulton Carbons.			*Buffalo Carbons.*		
	I.	II.	Average.	I.	II.	Average.
Carbon	98·19	98·24	98·21	97·68	......	97·68
Hydrogen	0·72	......	0·72	1·51	1·60	1·55
Ash	0·87	0·88	0·87½	1·09	1·08	1·09
Occluded air or loss	0·22		0·19	......		......
	100·00	99·12	99·92	100·28		100·32

	Carré Carbons.		
	I.	II.	Average.
Carbon	95·98	95·84	95·91
Hydrogen	1·00	0·73	0·86
Ash	1·91	1·83	1·87
Occluded air or loss	1·11	1·60	1·36
	100·00	100·00	100·00

In looking at these figures, several points of interest at once present themselves.

The Brush carbons have the smallest ash of the series. On account of their rather more open and porous structure, there is room for occluded air in this case, as the result shows.

The Wallace carbons have the largest amount of ash of the series.

The character of this ash will be noted farther on by another member of the Committee. This carbon is closer in structure than the Brush carbon, being made in an entirely different way, and there is no occluded air to look for.

The Boulton carbons, though having a higher percentage of ash than the Brush carbons, have a higher carbon and a lower hydrogen percentage, possibly having been burned at a higher temperature.

The Buffalo carbons show a distinctly higher percentage of ash than the Brush or the Boulton carbons. The hydrogen percentage as given is possibly a little too high, as the summing up seems to show.

The Carré carbons show a large ash, although considerably less than the Wallace carbons. The porous structure of these hydrocarbons offers, no doubt, a partial explanation for the relatively large percentage of occluded air and loss.

2. *Determination of the percentage of ash and qualitative examination of same.*—This was undertaken by Dr. Charles B. Dudley, and the examination was made upon a portion of the same pulverized material as that used by Prof. Sadtler in the combustion analyses. The results were as follows:

The Brush carbons yielded 0·478 per cent. of ash. A qualitative examination showed that the portion insoluble in acids was slight; that there was a considerable amount of ferric oxide and a trace of magnesia.

The Wallace carbons yielded 2·672 per cent. of ash. A qualitative examination showed a large insoluble residue and a large amount of the oxides of copper and iron.

The Boulton carbons yielded 0·892 per cent. of ash. A qualitative examination showed a small insoluble residue only, a large amount of ferric oxide and a trace of magnesia.

The Buffalo carbons yielded 1·104 per cent. of ash. A qualitative examination showed a small insoluble residue, much ferric oxide, and a trace of magnesia.

The Carré carbons yielded 2·086 per cent. of ash. A qualitative examination showed considerable insoluble residue, much ferric oxide, and considerable lime.

It will be seen that these ash determinations correspond quite generally, in some cases with great exactness, to those gotten in connection with the combustion analyses of the carbons.

Sample.	Length of coating.	Copper on length of 4 c. m.	Copper per centimetre.	Total copper (not including that on end).
Brush carbon......	281 millimetres.	·1621 grammes.	·040525 grammes.	1·1388 grammes.
Wallace carbon...	297 "	·0180 "	·00 "	0·1337 "
Boulton carbon...	272 "	·1853 "	·046325 "	1·2600 "
Buffalo solid carbon...................	262 "	·1010 "	·02525 "	0·6616 "
Buffalo core carbon.....................	253 "	·1525 "	·038125 "	0·9645 "

3. *Determinations of copper on the copper-coated carbons.*—These were made, by Prof. Wm. H. Greene, upon the samples of the Brush Company, the Wallace Company, the Boulton Company, and both the homogeneous and the graphite-core carbon of the Buffalo Company. No copper-coated sample of the Carré carbon was exhibited. The results are given in tabular form on page 17.

4. *Specific gravity determinations.*—These were undertaken by A. E. Outerbridge, Jr., and were made upon the uncoated carbons of the Brush, Wallace and Boulton Companies, the French Carré carbon and the plain, the graphite-core and a glazed carbon of the Buffalo Company.

A superficial examination of these carbons showed that some of them were much more porous and of coarser grain than others; it was thought advisable, therefore, to make two different determinations of each sample, one for the purpose of ascertaining the specific gravity of the pencil and the other the specific gravity of the material of which the pencil is composed.

For the first method the samples were all cut to the same length, viz., 5 centimetres. These were first heated to a moderate temperature to expel the moisture absorbed in their pores and further dried in a desiccator; when quite cool they were weighed upon a delicate analytical balance, sensitive to less than one-tenth of a milligram. The pencil was then coated with shellac varnish to prevent the absorption of water when immersed. When the thin coating of shellac was hard the sample was suspended from the beam by a filament of silk and reweighed; this was the weight used in the specific gravity determinations. The sample was then immersed in a beaker glass of distilled water at 60°F. and weighed. The specific gravity of the pencil was then determined by the usual calculation.

In order to determine the specific gravity of the material of which the pencils are composed, it was first ground to a fine powder in a steel mortar, put through a "No. 80" sieve, warmed to expel moisture, dried in the desiccator and weighed. The weight taken in this case was usually two grammes. The specific gravity bottle which was used in these determinations was filled each time with distilled water at, or very near, 60°F., and weighed; the water was then poured out, the powder put in, the bottle refilled with water (care being taken that no air-bubbles remained) and reweighed; from which data the specific gravity of the sample was determined.

In addition to the above, two other experiments were made, as follows: The pencil was broken up in the mortar and the finest particles separated by the sieve; the coarser grains were weighed, thrown into distilled water and boiled. The water was then cooled down to 60°F., the granules transferred to the specific gravity bottle and a new determination made. In both cases, the specific gravity was much higher than that of the finely powdered portion of the same sample, as will be seen from the tabular statement appended. This would seem to indicate that some volatile gas was driven off during the process of boiling.

A further observation was made, viz.: that the material composing the pencils is not of uniform density. When the sample is finely powdered, thrown into water and stirred with a glass rod, a portion sinks, but another portion (somewhat like an oily scum) floats upon the surface. This is doubtless some pitch or tar compound used to cement the materials together. Most of the carbons used in actual practice are coated with a superficial layer of copper, and as this would render specific gravity determinations of no value, the plain carbons only were used with the exception of one sample exhibited by the Buffalo Co., covered with a coating of borate of lead. There was also a carbon pencil examined having the peculiarity of a central core (resembling graphite) a little larger in diameter than the core of an ordinary lead pencil.

It was noticed when these different determinations were tabulated that the specific gravity of the powdered carbon was (as might be expected) in each case greater than that of the pencil, and furthermore that the pencils showing the highest specific gravities were not made from the densest materials. Considerable difference was also noticed in the hardness of the different samples.

The figures given in these tables are the average of two weighings of the same sample after drying.

Carbon Pencils.

Name of Sample.	Length.	Weight.	Specific Gravity.
Brush	5 centimetres.	7·8035 grammes.	1·526
Wallace	do.	8·5667 "	1·571
Boulton	do.	7·7162 "	1·516
Buffalo—plain	do.	7·7272 "	1·523
Buffalo—graphite core	do.	7·0540 "	1·415
Buffalo—vitrified	do.	8·5961 "	1·598
Carré	do.	8·6091 "	1·506

Ground Carbon.

Name of Sample.	Weight.	Specific gravity
Brush	2 grammes.	1·587
Wallace	do.	1 806
Boulton	do.	1·606—1·540 Average, 1·573
Buffalo—graphite core	do.	centre core, 1·699 exterior, 1·594
Buffalo—vitrified	do.	1·865
Carré	do.	1·885—1·914 Average, 1·8995

The following table shows the specific gravity of the two coarsely powdered samples which were boiled in distilled water.

Brush carbon	2 grammes taken	sp. gr., 1·908
Carré	do	sp. gr., 1·982

5. *Microscopical examination of thin transverse sections of the carbons.*—This was made by Dr. Persifor Frazer and yielded the following very interesting results.

The examination of the five thin sections of the electric light carbons submitted was undertaken with an 8–10 Zentmayer lens and a Beck parabolic reflector.

The sections were in fair order (with the exception of some dirt on the inner surfaces of the cover glasses) except that No. 5 was broken across the cover glass and the latter as well as the carbon section detached from the slide.

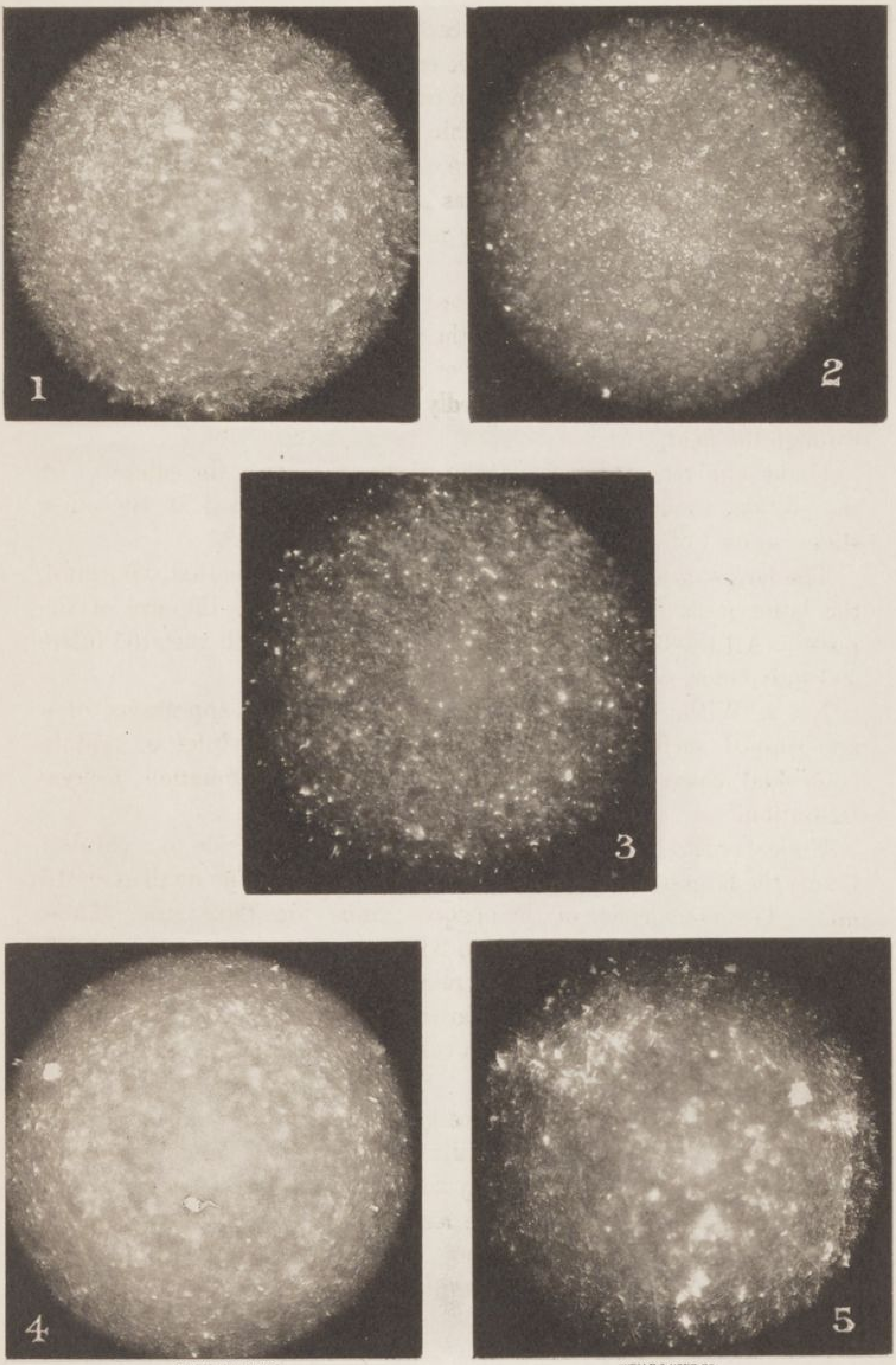

PHOTO-COLLOTYPE

WELLS & HOPE CO.

CARBONS FOR ARC LAMPS.

Photographs through the Microscope of thin Sections of Electric Light Carbons, to accompany Dr. Frazer's report.

BY W. CURTIS TAYLOR, PHOTOGRAPHER.

No. 1, was taken from a Brush carbon.

No. 2, was taken from a Wallace carbon.

No. 3, was taken from a Boulton carbon.

No. 4, was taken from the Buffalo Co.'s carbon.

No. 5, was taken from the Carré carbon.

The preliminary examination was made without a reflecting mirror and with a low eye-piece giving a magnifying power of about 50 diameters.

No. 1. Under these circumstances No. 1 presented an opaque surface except in a few spots where the film was torn away, and a few translucent particles. The color of its surface was silver gray with foliated masses of carbon of decidedly graphitic appearance distributed through the field.

Under the reflected light of the parabolic mirror the substance of the section, though of coarser structure than appeared in the other slides, seemed of considerable constancy of composition.

The largest grains were about 0·1 mm., and the smallest 0·03 mm., the latter measurement quite accurately representing the size of the pores. All the bright spots are surfaces showing high metallic lustre and gray color, with lines of striation and fracture.

No. 2. Without the reflector, No. 2 presented the appearance of a fine-grained surface covered with small rounded nodules or minute botryoidal masses, and showed little if any traces of foliation or crystallization.

Under reflected light (and exposed on the underside to a parallel beam) the largest opaque grains were 0·03 mm. and the smallest 0·015 mm. The average size of the opaque grains was 0·02 mm. These are, in a rough estimate, from 1 to 2 per cent. of visible foreign matter in the carbon in the form of grains of various substances (which are generally translucent) in the carbon. Some of these reach a size of 0·1. There are fewer pores in this than in No. 1, but those which exist are larger.

The largest part of the substance is very fine grained, but large dark gray angular discs are very generally distributed throughout the mass. In the photograph these dark gray flat bodies are visible, and the constituent parts of the fine mass are less sharply defined and separated. But, in fact, the photograph cannot give either the color or the lustre of the original, and is mainly useful in giving an idea of the texture of the surface.

No. 3. Without the reflecting mirror, No. 3 showed an extremely fine-grained texture with comparatively few and quite small points of silver-gray color and metalloid lustre.

Under the mirror, the grains measured from 0·05 to 0·02.

The texture was extremely fine-grained and compact, and the structure exceedingly homogeneous. The color of the surface was a lighter gray than that of any of the other slides, and was tinged yellowish in irregular blotches which may, however, have been the result of the accidental addition of a foreign body in mounting. Occasional translucent oblong particles were seen measuring 0·1 mm. to 0·05 mm. along their longer sides.

The surface exhibits small and large masses of slightly greenish color attached to each other and nowhere separable into distinct grains. The smallest of these constituent parts are not so small as those of the matrix of No. 2; and the largest, not as large as the dark angular fragments in the same slide. The structure is nowhere compact, but loose and spongy. There are visible a few small striated particles of irregular outline.

No. 4. Without the mirror the texture appears very fine, but little granular in character. The very small points of steel-gray color of graphitic aspect are less numerous than in 2 and 3.

With the reflector, the grains varied in size from 0·01 mm. to 0·03 mm., the average being rather nearer to the first measurement. The color was a somewhat darker gray than that of No. 3, and the number of very minute particles of foreign matter was greater, most of these were translucent and measured about 0·02 mm.

No. 5. Examined simultaneously in reflected and transmitted light, No. 5 shows a very large number of holes which have doubtless been caused by the more ready crumbling of certain of its constituent grains. Those of the latter which are opaque measure from 0·02 mm. to 0·01 mm. The grains are not so fine as in the last specimen, and the structure seems to be less homogeneous.

From the existence of numerous very fine points of various colors in transmitted light, and the existence of the holes formerly mentioned, it would seem that the powdered carbon has been mixed with very fine sand or earth, either accidentally or purposely, before having been moulded into sticks.

The ground mass has a fine grained, dark greenish appearance of the same character as that of 3 and 4, *i. e.*, resembling a surface of a decomposing mineral. A number of dark gray, flat, angular objects are scattered through the mass as in No. 2.

RESISTANCES OF ARC LIGHT CARBONS.

The following measurements of resistances of electric light carbons were made at Cornell University last winter. The carbons were selected at random from those which Professor Sadtler procured for tests, and probably represent a fair average.

The method pursued in measuring the resistances was as follows: The carbon to be tested was connected in circuit with a piece of very uniform German silver wire, a known length of which measured $\frac{1}{10}$ ohm. To connect the carbon in the circuit, a hole, which the carbon fitted tightly, was bored in the side of a wooden block, and a second hole bored from the top of the block to meet the first. Such a block was fitted upon each end of the carbon and the vertical holes filled with mercury. Into this the connecting wires were placed. The resistance of the carbon was determined by obtaining, upon the German silver wire, points having the same difference of potential as points on the carbon near the two ends. Measuring the distance between these points on the German silver wire, and comparing with the known length for $\frac{1}{10}$ ohm, gave the resistance of the carbon. To determine the points of equal difference of potential, a Thomson galvanometer of 10,000 ohms resistance, differentially wound, was used. The coils were adjusted so that no deflection occurred when the same current flowed in opposite directions through them. Their resistances were also adjusted to exact equality. The terminals of one pair of coils were then connected with points near the ends of the carbon, and the terminals of the other pair with sliding contacts on the German silver wire. The method of using the instrument will now be evident. It was far more sensitive than was necessary for the purpose, but could nevertheless be used with great facility. The measurements were made by Mr. E. T. Turner, a young man doing some post-graduate work in my laboratory. The results are given in the table below:

Resistances of Carbons.

No. of Carbons.	Resistance per Centimeter.	Total Resistance of 30 c.m.
	WALLACE (PLAIN).	
1	ohm. 0·0048	0·134
2	0·0044	0·132
3	0·0047	0·141
	(COPPERED.)	
4	0·0044	0·132
5	0·0031	0·093
	BUFFALO COMPANY (VITRIFIED).	
	0·0050	0.150
2	0·0063	0·198
3	0·0061	0·183
	BRUSH (PLAIN).	
1	0·00610	0·183
2	0·00623	0·187
3	0·00672	0·222
4	0·00691	0·227
	(COPPERED.)	
1	0·00108	0·0324
2	0·00033	0·0099
3	0·00024	0·0072
	BUFFALO (PLAIN).	
1	0·00625	0·187
2	0·0052	0·156
	(COPPERED.)	
1	0·00221	0·076
2	0·00940	0·0144
3	0·00075	0·0225
	CORED (PLAIN).*	
1	0·1413	4·239
2	0·1700	5·100
	(COPPERED.)	
1	0·000122	0·01266
2	0·001617	0·04851
	BOULTON (COPPERED).	
1	0·00163	0·0489
2	0·00218	0·0654
3	0·000475	0·001425
	CARRÉ (PLAIN).	
1	0·00408	0·1224
2	0·00377	0·1131

*This was a hollow carbon having a core of some different material. To make sure that the high resistance was not a mistake, it was measured also in the ordinary way by the bridge, with the same results.

Respectfully submitted,

SAMUEL P. SADTLER, *Chairman Section VI.*
CHAS. B. DUDLEY, PERSIFOR FRAZER,
WM. H. GREENE, WILLIAM A. ANTHONY,
A. E. OUTERBRIDGE, JR.

NOTE.—Sincere thanks are due to Mr. William Curtis Taylor for the care, skill and time he has contributed to render the photographic plate as successful as possible. P. F.

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REPORT OF EXAMINERS
OF
SECTION X.

STEAM BOILERS.

"Merrihew Print," 501 Chestnut St., Phila.

8334

JUL [illegible] 1905

Philadelphia
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(SECTION I, CLASS VI, OF THE CATALOGUE.)

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EDITING COMMITTEE.

PERSIFOR FRAZER, *Chairman.*
CHARLES BULLOCK,
THEO D. RAND,
COLEMAN SELLERS,
WILLIAM H. WAHL.

t.c. - June 1, 1904 - G.W.C.
9.9.B. No. 2.6/06

INTERNATIONAL ELECTRICAL EXHIBITION, 1884.

FRANKLIN INSTITUTE, Philadelphia, Pa.

REPORT OF EXAMINERS.

SECTION X.—STEAM BOILERS.

To the Board of Managers, Franklin Institute:

GENTLEMEN:—I have the honor to transmit herewith the report of the Examiners of Section X, on Steam Boilers.

Respectfully,
M. B. SNYDER,
Chairman Board of Examiners.

PHILADELPHIA, *December*, 1884.

PROF. M. B. SNYDER,
Chairman Board of Examiners, International Electrical Exhibition:

SIR:—The Examiners in Section X (on Steam Boilers), respectfully present the following report.

H. W. SPANGLER, *for Section X.*

PHILADELPHIA, *December*, 1884.

REPORT ON STEAM BOILERS.

U. S. S. Tennessee, New Orleans, La.
February 13, 1885.

To the Chairman of the Board of Examiners on Steam Boilers.

Gentlemen :—Enclosed I send you a copy of the results of tests made during the late International Electrical Exhibition, together with an account of the methods used, and the deductions from the results.

The drawings of all the boilers are in the possession of Professor Marks, and I would recommend that they be reproduced for the report. I have not that data with me which can be taken directly from the drawings, and have left blanks wherever, in the description of the boilers, data should be filled in.

The thanks of the Committee are due to the Crosby Steam Gauge and Valve Company, for the use of their standard steam gauges and test pumps; also to Mr. M. B. Edson for his recording and alarm gauge, which was used in each of the tests; also to the Blake Manufacturing Company, for the use of two pumps for feeding boilers during the tests; and to Riehlé Brothers and Mr. Troemner for the use of scales during the tests.

The following named young men rendered valuable assistance in observing and recording the data during the tests, and are especially entitled to the thanks of the Committee.

Geo. R. Green,
Charles H. Small,
George K. Fischer,
W. F. Lubbe,
L. F. Roudinella,
H. Szlapka,
F. Thibault,
E. E. Alcott,
Wm. A. Bigler,
Theodore Gould, Jr.,
Thos. Grier.
Leon Kraft,
Richard McCall,
R. L. Rutter,
D. E. Tracy,
Joseph Israel,

All the calculations have been checked at different times by different computers.

Hoping the results and methods have been satisfactory to the Committee,

I am, very truly yours,

H. W. Spangler (*for Section X*),
Assistant Engineer, U. S. Navy.

Code of the Proposed Quantitative Tests for the Evaporative Efficiency of Boilers at the International Electrical Exhibition, by the Franklin Institute, of 1884.

SPECIAL NOTICE.

Boilers may be exhibited and used at the International Electrical Exhibition, but will not have quantitative tests made of their efficiency unless formal application is made, and the subjoined code accepted before July 15, 1884.

Competitive tests will not be made unless at the joint request of the parties desiring a competitive test, and after they have agreed to and subscribed to this code, and fixed upon a rating for the points enumerated in Article 4.

The Committee of judges reserve the right to limit the number of tests made, should time and opportunity not permit all the tests desired to be completed.

SECTION I.—PRELIMINARIES TO THE TESTS.

ARTICLE 1. (Capacity.) The boilers entered may be of any capacity having an evaporative power, not less than seven hundred and fifty pounds of water per hour.

Each boiler must be so drilled as to enable its whole internal capacity to be determined by being completely filled and emptied of water. Proper cocks, piping, etc., must be so placed as to enable this to be done readily.

ART. 2. (Pipes and Valves.) Each exhibitor will furnish all the pipes and valves necessary to make connection with the main water and steam pipes in a proper manner, and subject to the orders of the Superintendent. He will also make any alterations in water and steam pipes required for the tests, furnishing all tools, piping, cocks, and mechanical labor at his own cost.

ART. 3. (Space.) Each exhibitor will be furnished with space at the regular rates established for the exhibition, in which space he must build his foundations and boiler setting, and make connection with the chimney flue, if required, at his own cost, and subject to the approval of the Superintendent.

ART. 4. (Specifications.) Each exhibitor must furnish to the Chairman of the committee of judges on steam boilers, such description and drawing, both of the boiler in position and of the details of the boiler, as will facilitate the labor of that committee, together with his claims as to meritorious points for his exhibit.

The following points will have special consideration :

1. Economy of fuel.
2. Economy of material and labor of Construction.
3. Evaporative power. (Space occupied.)
4. Simplicity and accessibility of parts.
5. Durability of whole structure.

Exhibitors desiring a competitive test made, must agree upon a rating for these points before it will be made.

Exhibitors must also file the following data :

Area of heating surface to the nearest hundredth of a foot.
Area of grate surface to the nearest hundredth of a foot.
Area of calorimeter to the nearest hundredth of a foot.
Area of chimney flue to the nearest hundredth of a foot.
Height of chimney required.
Number of pounds of coal per square foot of grate to be burned per hour.

Should the calculations of the committee of judges differ in result from those of the exhibitor, he will be required to give all the details of his calculations, and an agreement must be reached before proceeding with the test.

SECTION II.—PREPARATIONS FOR THE TESTS.

ART. 5. (Coal). Anthracite coal will be used and will be furnished free of charge, provided the steam made is used for the general purposes of the Exhibition.

The same quality and size of coal will be used in all the tests, unless special arrangements be made for another kind of fuel.

An analysis will be made of the coal used. The coal will be weighed to the boiler.

ART. 6. (Water). The water used will be taken from the city mains. The feed water for the boilers will be weighed by means of scales and a large tank, and will be run into a smaller supplemental tank, from which it will be pumped into the boiler by means of a feed pump actuated by steam from the boilers.

The temperature of the feed water will be taken by means of a standard thermometer, in the supplemental tank.

ART. 7. (Pressure.) The steam pressure used shall not exceed ninety pounds per square inch by the guage, unless by special arrangement with the committee of judges.

A standard guage will be used and also a standard thermometer immersed in a mercury pocket in the steam space.

ART. 8. (Safety Valve.) The safety valve will be set to blow off at ten pounds above the pressure fixed upon.

ART. 9. (Leaks.) Within twenty-four hours preceding the test of a boiler, it must be subjected to hydraulic pressure, ten pounds greater than its steam pressure during the test, and proved to be perfectly tight.

ART. 10. (Attendants.) The attendants in charge of the boiler tested must be approved by the party whose boiler is tested and by the judges. All attendants are to be subject to the orders of the judges during the progress of the test.

ART. 11. (Ashes.) All ashes will be weighed on being withdrawn from the ash pit, and must not be damped until weighed.

ART. 12. (Calorimeters.) The calorimeters used will consist of a barrel, scale and hand thermometer. Two calorimeters will be used and simultaneous observations made at fifteen minute intervals.

ART. 13. (Fires.) The exhibitor shall be allowed one day previous to the test to clean boilers and grates.

The steam having reached the required pressure, the ash pit shall be thoroughly cleaned and swept, and thereafter the fire maintained as nearly uniform as possible, the test closing with the same depth and intensity of fire as it opened.

This point is to be decided by the judges who may make allowance if it be clearly shown to have been imposible to maintain uniform fires.

If in the judgment of the committee of judges the firing is inefficiently or improperly done, the test may be terminated at any time, and a repetition of the test refused.

Art. 14. (Pyrometer.) The temperature of the gases of combustion immediately upon entering the chimney flue shall be taken by means of a suitable pyrometer, read at fifteen minutes intervals, and close to the boiler.

Art. 15. (Manometer and Barometer.) The vacuum in the chimney flue shall be taken by means of a water manometer read at fifteen minutes interval. A barometer will be read simultaneously.

Art. 16. (Duration.) Unless otherwise arranged, the tests will last ten hours.

Art. 17. (Economy and Efficiency of the Boiler.) The level of the water in the boiler and the state of the fire must be kept as nearly constant as possible during the whole of the trial.

The weight of the water in the boiler for each one quarter of an inch, on the glass water guage, will be carefully determined and recorded previous to the test, and proper correction for unavoidable changes of level made.

The weight of water fed to the boiler, subject to proper corrections, will be multiplied by its observed thermal value as steam. From this product the thermal units of heat brought in by the feed will be subtracted.

The remainder will be divided by nine hundred and sixty-six and seven-hundredths British thermal units, giving the number of pounds of water evaporated from and at two hundred and twelve degrees Fahrenheit.

This latter quantity will be divided by the weight of coal burned, less weight of dry ashes, giving the number of pounds of water evaporated per pound of combustible. This shall be taken as the measure of the efficiency of the boiler.

The nominal horse-power of the boiler will be deduced by dividing the number of pounds of water evaporated from, and at two hundred and twelve degrees Fahrenheit per hour by thirty.

The evaporative power of the boiler will be determined by dividing the normal horse-power of the boiler by the number of cubic feet of space it occupies.

The space occupied by a boiler and its appurtenances will be regarded as the product of the square feet of floor space occupied by its extreme height in feet.

Methods Used in Testing Boilers.

All the boilers tested by this committee were located in a boiler-house to the north of the exhibition building proper, this boiler-house being open to the weather on the sides. It is probable that the boilers would have shown a higher efficiency, had the boiler-house been entirely enclosed, as the weather was quite cold during part of the tests.

The methods used were, as nearly as possible, the same for each boiler, and are given in detail below.

WATER.

All the water fed to the boilers during the tests was taken from two large tanks, each holding about 2,400 pounds of water, when full. In starting each test, the water-level in the boiler was noted, and all water put into the boiler after the test began was taken from the above-mentioned tanks which were alternately weighed and emptied. At the end of a test, the water-level in the boiler was brought to the same point as at starting, and the amount of water left in the tanks weighed and properly accounted for.

The steam pumps used on all the boiler tests worked very satisfactorily, there being no leaks about either pumps or pipes.

Before testing a boiler, a joint on each water pipe leading to the boiler was broken, and all the pipes disconnected excepting the one feeding from the pump used in testing.

SCALES.

The scales used for weighing feed water and coal were of Riehlé's make, and those used for the calorimeters were partly of Fairbank's and partly of Riehlé's make. All the scales were very accurate and were checked by comparison with Fairbank's standard weights of 50 pounds each.

TEMPERATURE OF FEED WATER.

The temperature of all water fed to the boilers was taken at intervals during the tests, and the mean of these temperatures was taken as the temperature of the feed. The thermometers used were made by J. & H. J. Green, of New York, and were very accurate.

COAL.

The coal used in these tests was purchased at different times and the size was as desired by the exhibitors of the various boilers. All coal was weighed in barrows and allowance made for all that was not used. The coal in all the tests was as it came from the dealer and was slightly wet. In each test a number of barrows full of coal were dried at the temperature of the air, and again weighed, but no appreciable loss of weight was perceptible. In the test of the Root boiler, the floor under the coal was constantly wet from water from the calorimeters used, but the greater part of the coal used was in the same condition as that used in the other tests.

A careful analysis of the coal was made under the direction of Professor Samuel P. Sadtler, from samples taken, from time to time, during the test by Mr. Spangler.

WOOD.

The wood used was such as happened to be most convenient, and was not all of the same kind, but the amount used was so small in comparison with the total amount of fuel, that the same allowance was made in each case for the relative values of coal and wood.

ASHES.

All ashes were weighed dry, and at the end of the test the fire was drawn, and where any unburnt coal came from the furnace, it was credited to the coal account, the remainder was charged to the ash account.

In the case of the Dickson boiler, the ashes were very wet as they were drawn from the ash pan, as the steam blower discharged directly into the ash pan. A number of barrows of ashes were weighed and the percentage of moisture was calculated from the weight after drying, and due allowance made for the same in the ash account.

BAROMETER.

The readings of the barometer were taken from the observations made by the United States Signal Service in Philadelphia, during the time of the tests.

THERMOMETER.

The temperature of the air was taken from the same source and agreed very closely with that taken during the tests.

STEAM PRESSURE.

The steam gauge used on the tests was furnished by the Crosby Steam Gauge and Valve Company. One of these gauges was tested by Thomas Shaw, of Philadelphia, with a mercury column for every five pounds from 0 to 120 pounds, both ascending and descending.

Before and after each test the gauge used on the boilers was carefully compared with this standard, both ascending and descending throughout the range of pressure used on the tests. The gauges were very accurate and agreed as well at the end as at the beginning of the set of tests. Readings were taken at frequent intervals, and the mean of these readings taken as the mean pressure of the steam.

In addition to the Crosby gauge used, an Edson Recording Gauge was attached to each boiler as it was tested, and records made during the entire test. The indications of this gauge were accurate and reliable, but the clockwork required frequent adjusting to keep the recording slip moving at a uniform speed. The alarm attached to the gauge was not used.

TEMPERATURE OF THE STEAM.

A large monitor thermometer was used for indicating the temperature of the steam. It was screwed into the steam space of the boiler, and its indications noted from time to time. These thermometers were a little slow in acting, as there was a considerable body of iron and mercury to change in temperature, but the indications are considered very reliable.

TEMPERATURE OF SMOKE-STACK.

In determining this temperature a monitor thermometer was inserted in the smoke-stack, just back of the damper in the Root, Baldwin, and Harrison boiler, and at the bottom of the smoke-pipe in the Dickson boiler. It was not practicable in all cases to put the thermometer in vertically. In the Harrison test it was vertical; in the Dickson test it was inclined at an angle of about 30 degrees to the vertical; and in the Root and Baldwin tests, the thermometer was inclined about 10 degrees from the horizontal. The bulb of the thermometer was put as near as possible into the centre of the flue, while the stem projected into the air. The openings into the flue around the thermometer were carefully closed so that no air could enter. Readings were taken as often as practicable from these thermometers, and the mean of the readings taken.

DRAFT IN CHIMNEY.

A number of devices were used for measuring the draft in the chimney. That used on the Root boiler was suggested by Professor Lanza, and was the design of Mr. Fisher, of the Massachusetts Institute of Technology. It consisted of two chambers *a* and *b*, Fig. 1, each covered by a rubber diaphragm *c* and *d*. The interior of the chamber *a* is connected with the interior of the chimney by means of a pipe *e*, supplied with a three-way cock so that the interior of *a* can be connected with the chimney or with the air. The interior of *b* is connected by means of a pipe to a vertical glass tube *f*, open at the top.

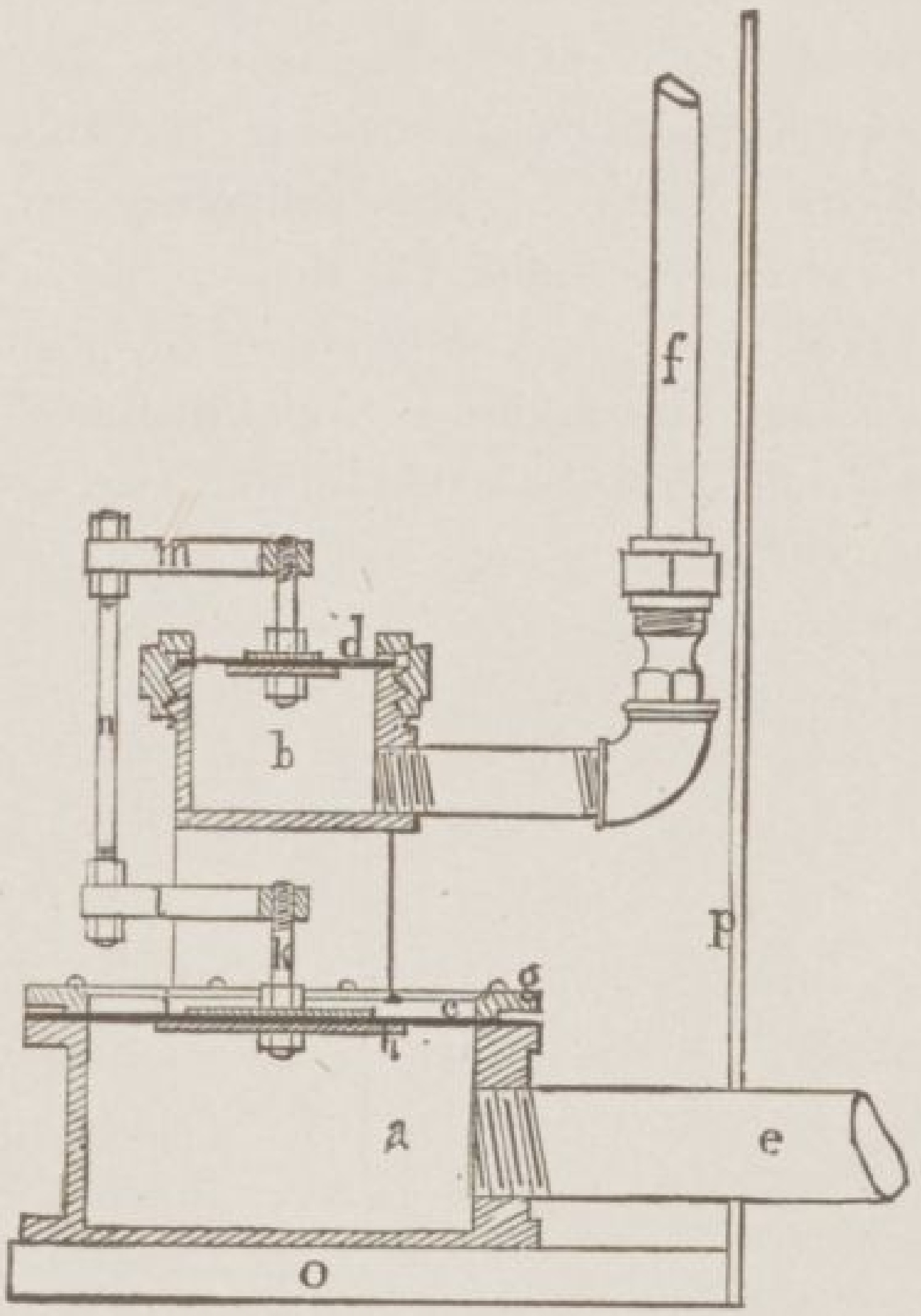

FIG. 1.

The chamber *b*, the glass tube *f*, and the connecting pipe are filled with water, the air being entirely excluded. The chamber *b* and all its attachments are carried on the annular ring *g*, which holds the rubber diaphragm of *a* in place. To the centre of the diaphragm *c* two plates *h*, *h*, are attached which support a vertical rod *k*. This rod screws into a cross-head *l*. To the diaphragm of *b* a similar cross-head *m* is attached in the same way, and these two cross-heads are connected by means of two side rods, only one of which, *n*, is shown. The whole apparatus rests on a base board *o*, which carries a vertical piece *p* to which a paper scale graduated in inches is attached. The method of using the apparatus is as follows: The three way cock in *e* being turned so that *a* is in communication with the air, the reading of the scale opposite the head of the water column is noted. The three-way cock is turned so that the inside of *a* is connected with the chimney, and the reading of the top of the column in *f* is again noted, and the difference between the readings is caused by the difference in pressure inside and outside the chimney. This difference divided by the ratio of the areas of the chambers *a* and *b* is the vacuum in the chimney in inches of water.

Comparison was made between this apparatus and the one referred to as the invention of Professor Webb, and the two methods were found substantially to agree.

As the Webb apparatus was more convenient, the one just described was used only on the Root boiler.

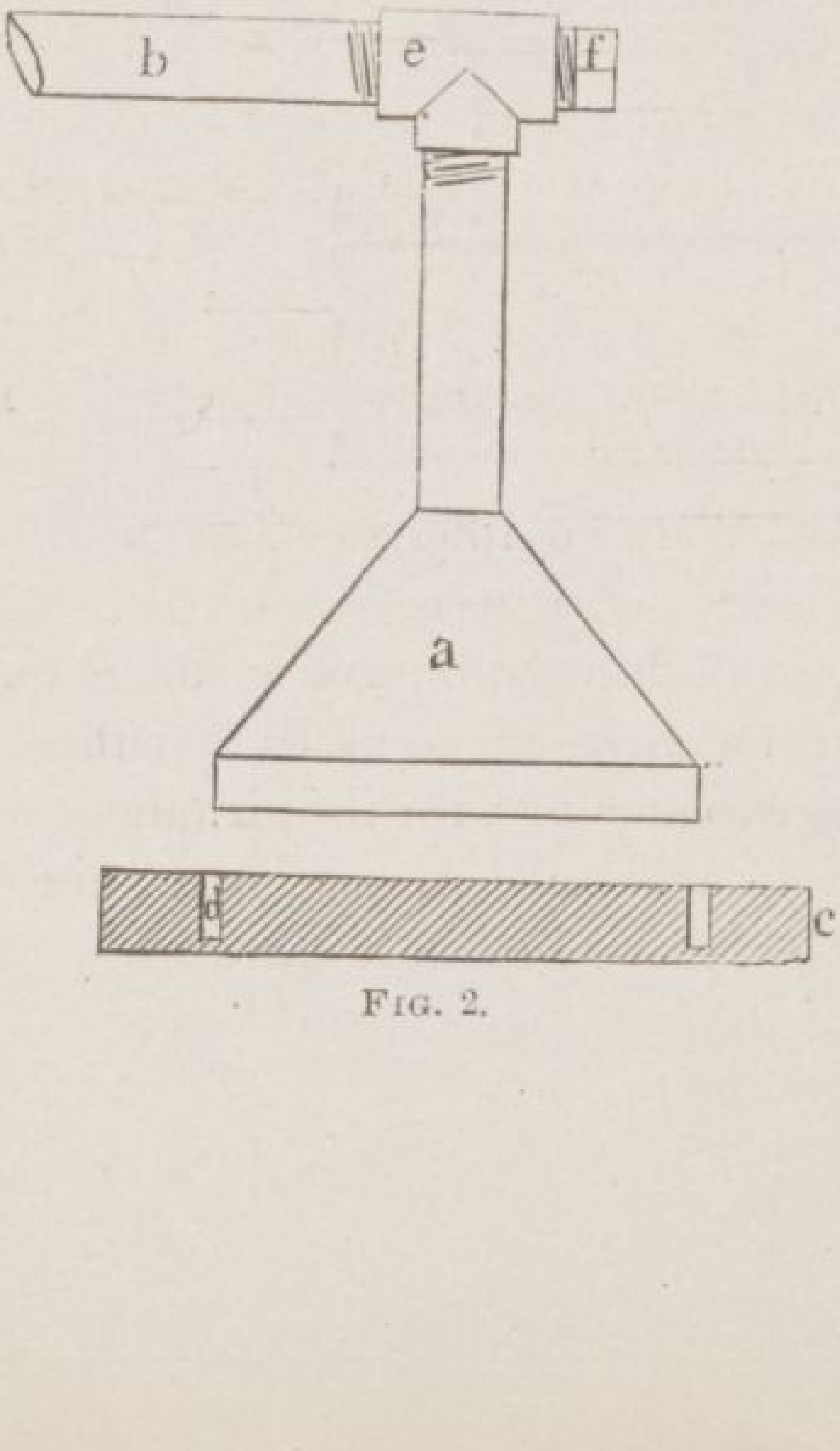

FIG. 2.

In testing the other boilers the following described apparatus, the invention of Professor J. Burkitt Webb, a member of the Committee, was used.

It consisted of an inverted funnel-shaped vessel, *a*, Fig. 2, whose interior is connected through the pipe *b* to the chimney. A piece of gas piping was put into the chimney and connected directly to the pipe *b*. The **T** *e*, had one end closed by a plug, *f*, so that, if desired, the interior of the funnel *a* could be connected to the air. The funnel *a* and pipe *b* were suspended over a board, *c*, having a circular groove, *d*, cut into its upper face. This board rested on a pair of Fairbanks' scales weighing to ounces. The groove *d* was filled with mercury and the edge of *a* dipped into this mercury.

The method of using the apparatus was as follows: The plug *f* being removed, the scales were balanced; the plug was then replaced, and *b* being connected to the chimney, the scales were balanced again and the difference or loss of weight noted. The loss of weight divided by the area of the mouth of *a* is the loss per square inch, and represents the difference in pressure inside and outside the chimney, and this multiplied by 1·728 gives the corresponding draft in inches of water. The apparatus worked very satisfactorily and the results are very reliable.

QUALITY OF STEAM.

One of the most difficult subjects presented to the Committee was the quality of the steam generated, and we do not think the results obtained are to be implicitly trusted. The data was taken as carefully as could be, but the imperfections of the apparatus were such, that it is a matter of much doubt as to how much reliance can be placed on the results.

There were a number of devices presented to the Committee for use and discussed in their meetings, and the three following described were adopted and used in the tests.

It will be noticed that two different methods of testing the quality of the steam from each boiler were employed, except in the case of the Baldwin boiler, and the results vary so much that no conclusions can be drawn as to the degree of accuracy of either.

While it may be considered that the apparatus giving the most regular results is most to be depended upon, I am satisfied that the conditions in the best boiler are such that the quality of the steam must be very variable, and it is doubtful whether a mean result is a satisfactory one or not.

The entire subject requires much more investigation than your Committee had the time to undertake.

BARREL CALORIMETER.

One apparatus used for testing the quality of the steam was an ordinary barrel resting on Riehle's scales. A quantity of water was put into the barrel and its weight noted. Just before making the experiment, the temperature of the water was noted. A steam pipe from the boiler led down to within a short distance of the barrel and was covered with felting. To the end of this pipe a short length of hose was attached. Everything being ready for the experiment, the steam was turned on the hose and allowed to blow into the air until apparently dry steam showed at the end of the hose. This end was then put into the barrel and the temperature of the water allowed to rise from 10 to 20 degrees, the water being constantly agitated. The hose was then taken out and the temperature of the water in the barrel noted. The weight was then taken and the pressure of steam during the experiment noted. From this data the quality of the steam was calculated.

In making the calculations, allowance was made for the water equivalent of the barrel used. The barrel being partly filled with water to the level used in the experiments and its temperature noted, a quantity of warm water of known temperature was added and the resulting temperature noted. Knowing the weights of water used, the equivalent of the barrel was found as follows: Multiply the added weight of water by the number of heat units lost by the warm water and divide by the heat units gained by the cold water. This quotient less the weight of cold water in the barrel is the water equivalent of the barrel.

Allowing the water to remain in the barrel for three minutes made no appreciable change in the temperature, showing that there was but little loss from radiation during each experiment, which did not generally last over two minutes.

The following formula was used in making the calculations from data derived while using this apparatus, and an examination of the results will show that they vary surprisingly.

w = weight of cold water plus water equivalent of barrel.
g = heat units corresponding to temperature of cold water, counting from 32°F.
g_1 = heat units corresponding to temperature of the mixture, counting from 32°F.
H = heat units (latent) corresponding to the temperature and pressure of steam.
g_2 = heat units (sensible) corresponding to the temperature and pressure of the steam, counting from 32°F.
w_1 = weight of water and steam added.
φ = water contained in w_1.

$$\varphi = 1 + \frac{1}{H} \left\{ (g_2 - g_1) - \frac{w}{w_1} (g_1 - g) \right\}$$

The numerical quantities used in making these calculations were taken from Röntgen's "Thermodynamics" (DuBois' translation), and are substantially the same as other tables derived from the same source, and were used because they were familiar to the young men making the calculations.

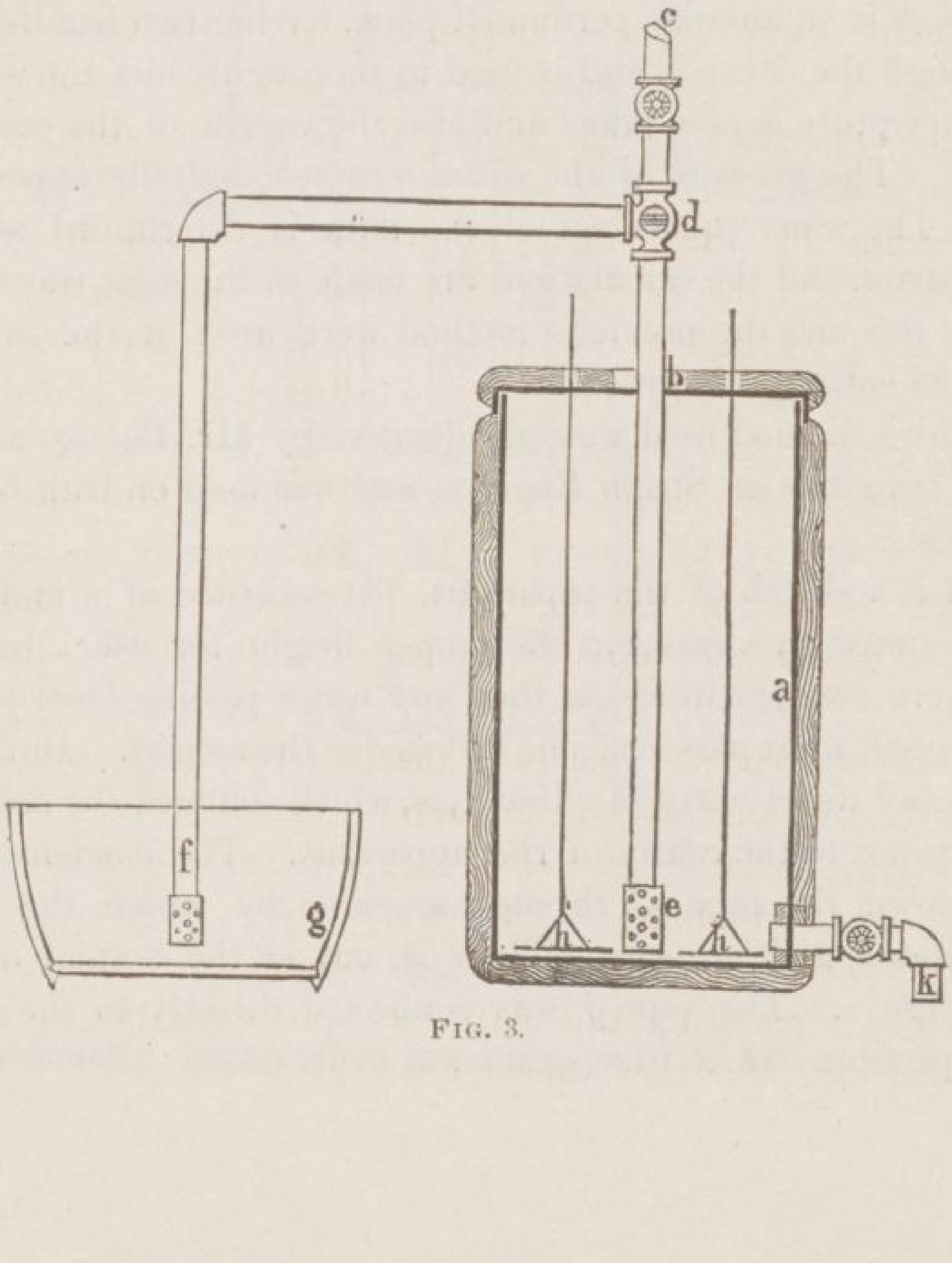

Fig. 3.

The second apparatus used was on the same general principle, and only differed from the first in matters of detail. It is shown in Fig. 3. *a* represents a tin tank, high in proportion to its diameter, and heavily covered with felt and canvas. A tin cover, *b*, fitting over this tank, had an opening in its centre for admitting steam or cold water. *c* is the pipe from the boiler, branching at the three-way cock *d*. One branch goes down into the tank *a*, and has the rose *e* at its lower end. The other branch terminates in the rose *f*, in the tank *g*, which is kept partly filled with water. *k* is the drain-pipe and valve for emptying *a*. The method of operating the calorimeter is as follows: The weight of the tank *a* is taken. It is then partly filled with water, and the weight and temperature is noted. Steam being off the pipe *c*, the three-way cock *d* is turned so that *c* and *f* are in communication. Steam is now turned on *c* and passes into the water in *g*. As soon as the pipe is heated and clear of any condensed water, the three-way cock *d* is turned and the steam allowed to pass into *a*. As soon as a sufficient quantity, say 10 pounds, has passed into *a*, the three-way cock is turned into its original position and steam is shut off *c*. *h*, *h* is an annular perforated plate, having two handles extending through the cover *b*, and is used to thoroughly mix the water in *a*. The temperature is now taken and also the weight of the tank and its contents. The pressure of the steam is noted, and the experiment is ended. The water equivalent of the tank is determined as for the simple barrel, and the calculations are made in the same way as before.

When this and the previous method were used at the same time, the results entirely disagreed.

The third method used was one devised by Mr. Barrus, a member of the Committee on Steam Engines, and was used on both boiler and engine tests.

Fig. 4 is a sketch of the apparatus. It consisted of a wooden vessel, *o*, mounted on a frame at the proper height for use. Inside this vessel were two partitions, so that any water passing from the centre of the vessel, must pass over one and under the second. In the centre of the vessel was a vertical cylinder, *m*, which confined the coldest condensing water to the centre of the apparatus. The condensing water passed down the pipe A, through a valve by which the quantity was regulated, and into the cylinder *m*, out at the bottom of *m*, and out through *c*. The pipe *j* was connected directly to the boiler or steam-pipe from which the steam was to be taken. Below the globe valve is shown a branch-pipe, forming a gauge siphon. Below the vessel *o*, there is attached to the main pipe a glass water-gauge, *e*, and below this there was a globe valve, *d*, which regulated the discharge of the condensed steam. A short piece of hose was attached and the condensed water was drawn off into two buckets set on accurate pairs of Fairbanks' balances. These buckets were partly filled with cold water and their weights were taken. A quantity of the condensed water was run into one, and before the temperature had risen to 100°F., the hose was moved to the other bucket. The weight of the bucket of warm water was noted and the difference of the weights is the weight of the condensed steam. The bucket was emptied and partly filled with cold water again.

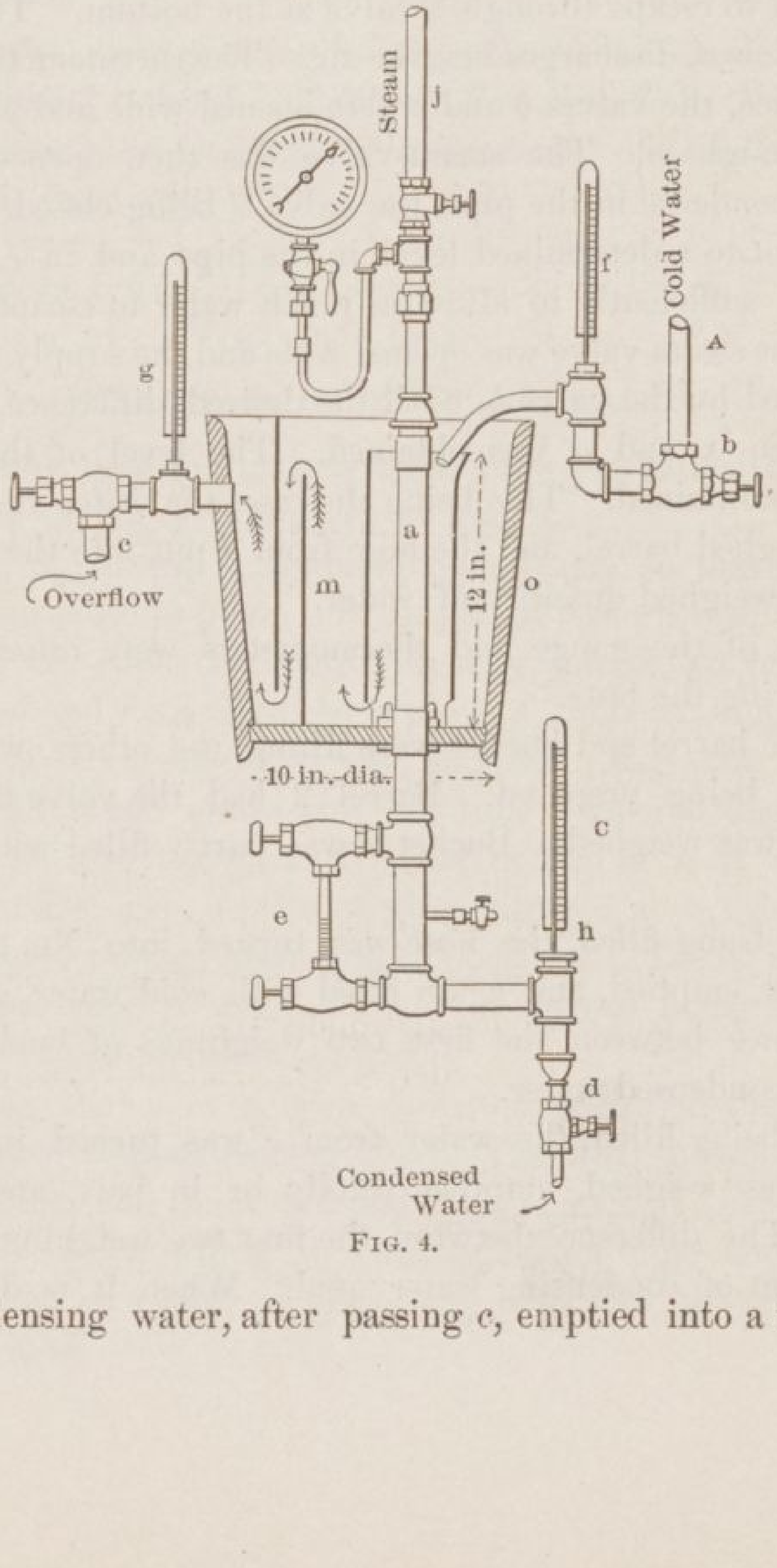

FIG. 4.

The condensing water, after passing *c*, emptied into a tank, which was supported over two barrels. The water could be directed into either at will. The barrels were weighed empty and full, and the difference taken as the weight of the condensing water.

The temperature of the condensing water was taken at *f*, before going into *o*, and at *g*, after doing its work. The temperature of the condensed water was taken at C, and the temperature of the live steam was taken from the corresponding pressure.

The method of operating the apparatus was as follows:

One barrel under *c* was empty and its weight known, and one bucket was partly filled with cold water and its weight known. Any water passing through *c*, flowed into the unweighed barrel and was allowed to escape through a valve at the bottom. The small hose attached below *d*, discharges into the air. The thermometers and gauge being in place, the valves *b* and *c* were opened wide and water allowed to flow through *m*. The steam-valve was then opened and steam allowed to condense in the pipe, the valve *d* being closed. As soon as the water got to a determined level in the pipe and in *e*, the valve *d* was opened sufficiently to allow as much water to escape as was condensed. The steam valve was opened wide and the supply of cold water was regulated by the valve *b*, until the desired difference of temperature between A and *g* was obtained. The level of the water in *e* should be maintained. This being the case, the water at *c* was turned into the weighed barrel, and the hose from *d* put into the bucket containing the weighed quantity of water.

Readings of the gauge and thermometers were taken every five minutes during the tests.

While the barrel and bucket were filling, the others, which we will call 2, were being prepared. Barrel 2 had the valve at the bottom closed, and was weighed. Bucket 2 was partly filled with water, and weighed.

Bucket 1 being filled, the hose was turned into No. 2, and No. 1 was weighed, emptied, and again filled with cold water, and weighed. The difference between the first two weighings of bucket 1 is the amount of condensed water.

Barrel 1 being filled, the water from *c* was turned into barrel 2. Barrel 1 was weighed, emptied wholly or in part, and was again weighed. The difference between the first two weighings of barrel 1 is the amount of condensing water used. When it is desired to end the experiment, the barrel and bucket in use should be changed at the same instant, and weighed, and the steam closed off.

One point to be particularly guarded against is the blowing of live steam into the buckets, as in that case the water in the buckets becomes part of the condensing water, and no provision is made for such a contingency.

The calculations were made in the following way: The total amount of condensing and condensed water was determined. The average of the readings of thermometers and gauge was found.

Using the same nomenclature as before, with the following addition and change, the quantity of moisture was determined by the following formula.

g_1 = heat units corresponding to temperature of condensing water after passing through calorimeter, counting from 32°.

g_3 = heat units corresponding to temperature of condensed steam, counting from 32°.

$$\varphi = 1 + \frac{1}{H} \left\{ (g_2 - g_3) - \frac{w}{w_1} (g_1 - g) \right\}$$

QUALITY OF GASES OF COMBUSTION.

The apparatus used for making these tests was loaned by Professor Denton, and a sketch of it is given in Fig. 5.

The entire apparatus is mounted on a frame, so that it can easily be moved from place to place. It consists of two glass tubes, *a* and *b*, each of about 120 cubic centimetres capacity, joined together by means of the necks *d* and *f* connected by a piece of rubber tubing *x*.

The neck of *b* extends vertically, and has a stop cock *c* above the connection with *d*, and above this the tube is tapered and ground to form a seat for the funnel *m*. To the bottom of *a* is attached, by means of a rubber cork, a piece of glass tubing *i*, to which is attached a piece of rubber tubing, leading to the bottle *k*. To the bottom of *b* a similar attachment is made, the only difference being that in the tube *g* a two-way stop cock *h* is fitted.

One opening, shown at *s*, opens downwards, so that the contents of *b* can be emptied without passing into *l*. The other opening is directly through the cock, and connects *b* and *l*. *n* is a small barrel having a pipe and valve *o* for filling it with water, *q* a pipe and valve for emptying it, and *p*, a piece of gas piping with cock, the uses of which will be explained.

The method of using the apparatus and making the tests is as follows:

The top of the tube *b* above *c*, is connected with the chimney whose gases are to be analyzed. The tubing connecting *g* and *l* is removed, and *g* and *p* are connected by means of tubing. The bottle, *k*, being filled with water, is raised until the water runs through *d*, *e* being open, and fills *d* to its connection with *b*. The cock *e* is then closed, and *k* is lowered to its original position.

The pipe *o* is connected with a hydrant, *q* is closed, the cock in *p* is opened, *c* is opened, and *h* is put in such a position that *b* and *n* are in communication. Water is allowed to run from the hydrant until *n*, *b* and the pipe connecting with the chimney are filled with water. *o* is then closed, and *q* is opened. The water flows back through *b*, and the chimney gas follows. After sufficient gas has been allowed to pass through *b*, the cocks *c* and *h* are closed.

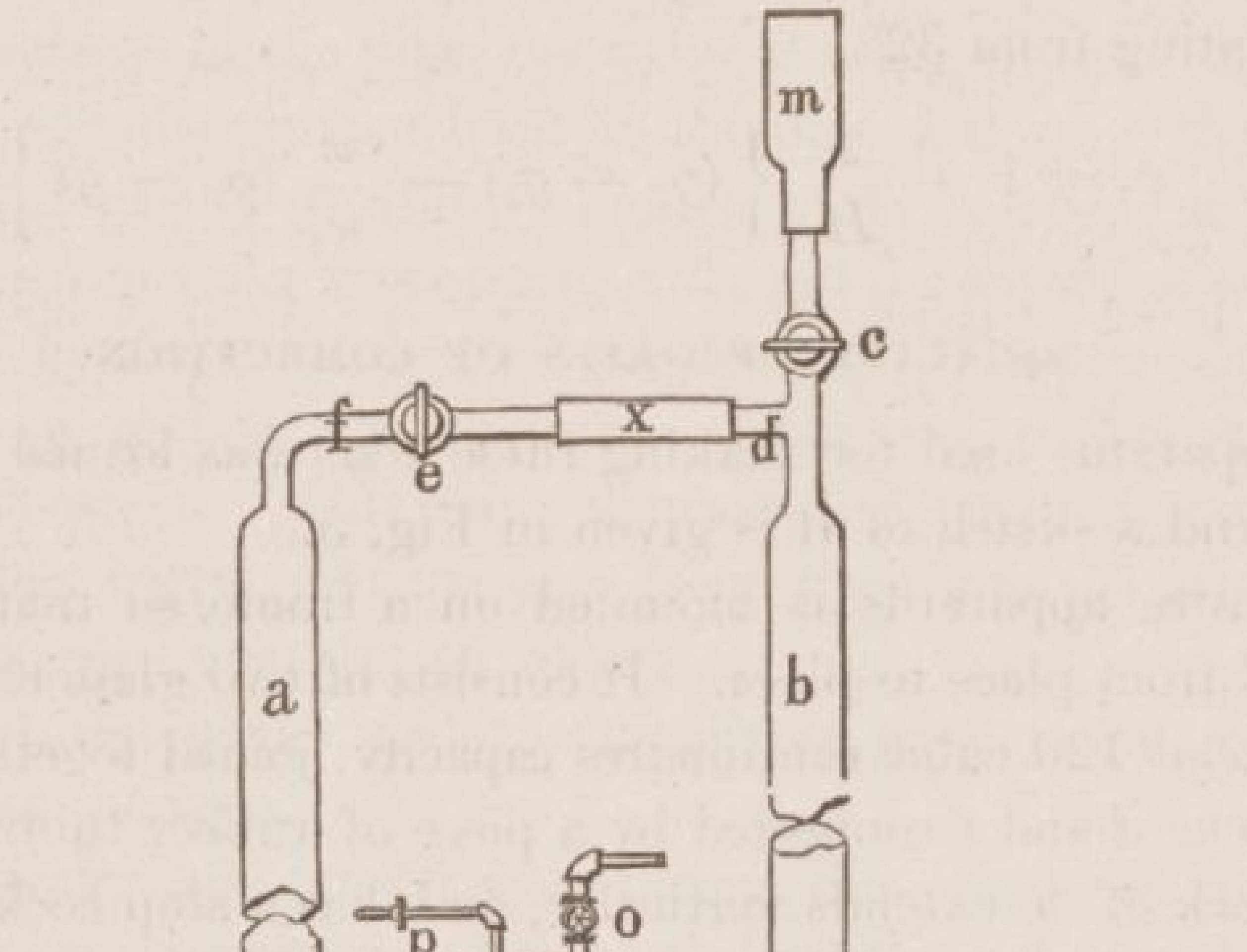

Fig. 5.

The tubing connecting *b* and the chimney, and that connecting *q* and *p*, are taken off, and the bottle *l* is again attached to *g*.

A certain volume of the chimney gas is now confined in *b*, and the apparatus can be moved to any convenient place for further work. The cock *c* being closed, *e* and *h* are opened, and the water is allowed to flow back into *k* until a certain quantity, say 100 cubic centimetres, of the gas is in *a*. The cock *e* is closed and the gas allowed to assume the temperature of the air. The cock *h* is turned so that *b* can be washed out, *c* is opened and the funnel *m* put on; *b* is washed out and filled with clear water from *l*, the cock *h* being again turned and *c* being closed; *k* is now raised until the level of the water in *a* and *k* is the same, and the reading of the scale on *a* is noted.

In the apparatus used, the volume was divided into cubic centimetres, beginning at the cock *e*, but any division into equal volumes would do equally well, and it is not at all necessary that 100 cubic centimetres, or 100 equal parts, should be used in the calculations.

The volume in *a* being noted, the cock *e* is opened, *h* being already so, and the gas is passed back into *b*.

The cock *e* is closed. The funnel *m* is partly filled with caustic potash, the cock *h* is closed and the cock *c* is opened until the greater part of the caustic potash has passed into *b*; *c* is now closed, *e* is opened and the gas again passed into *a*, where its volume is again noted, the level of the liquid in *a* and *k* being the same. As the caustic potash has absorbed all the carbonic acid (CO_2) in the gas, the difference in readings already taken is the volume of carbonic acid in the gas. The The tube *b* is washed out and the process is repeated, using pyrogallic acid in caustic potash, and copper chloride in hydrochloric acid. The first of these removes the oxygen, and the last the carbonic oxide (CO).

To determine the amount of air present per pound of carbon, add together the volume of O and CO and twice the volume of CO_2. Divide by the sum of the volumes of CO and CO_2, and $\frac{4}{3}$ the quotient is the weight of oxygen present per pound of carbon. This result divided by ·23 is the weight of air used per pound of carbon, and this result divided by the percentage of carbon in the coal is the weight of air used per pound of coal.

MAKING THE TESTS.

In making the boiler tests, steam was first raised to the working pressure in each boiler, and the fires were then hauled. All wood and coal used thereafter was weighed, and at the end of the test the fire was hauled, and any unburnt coal credited to the boiler.

Water in the boiler was carried as nearly as possible at one height, and at the end of the test was brought back to the same level as at the beginning of the test.

DURATION OF THE TESTS.

Each test lasted 36 hours, except in the case of the Baldwin boiler, where the test was terminated at the end of 24 hours.

The following are the results of the different tests, together with the results derived from the observed data.

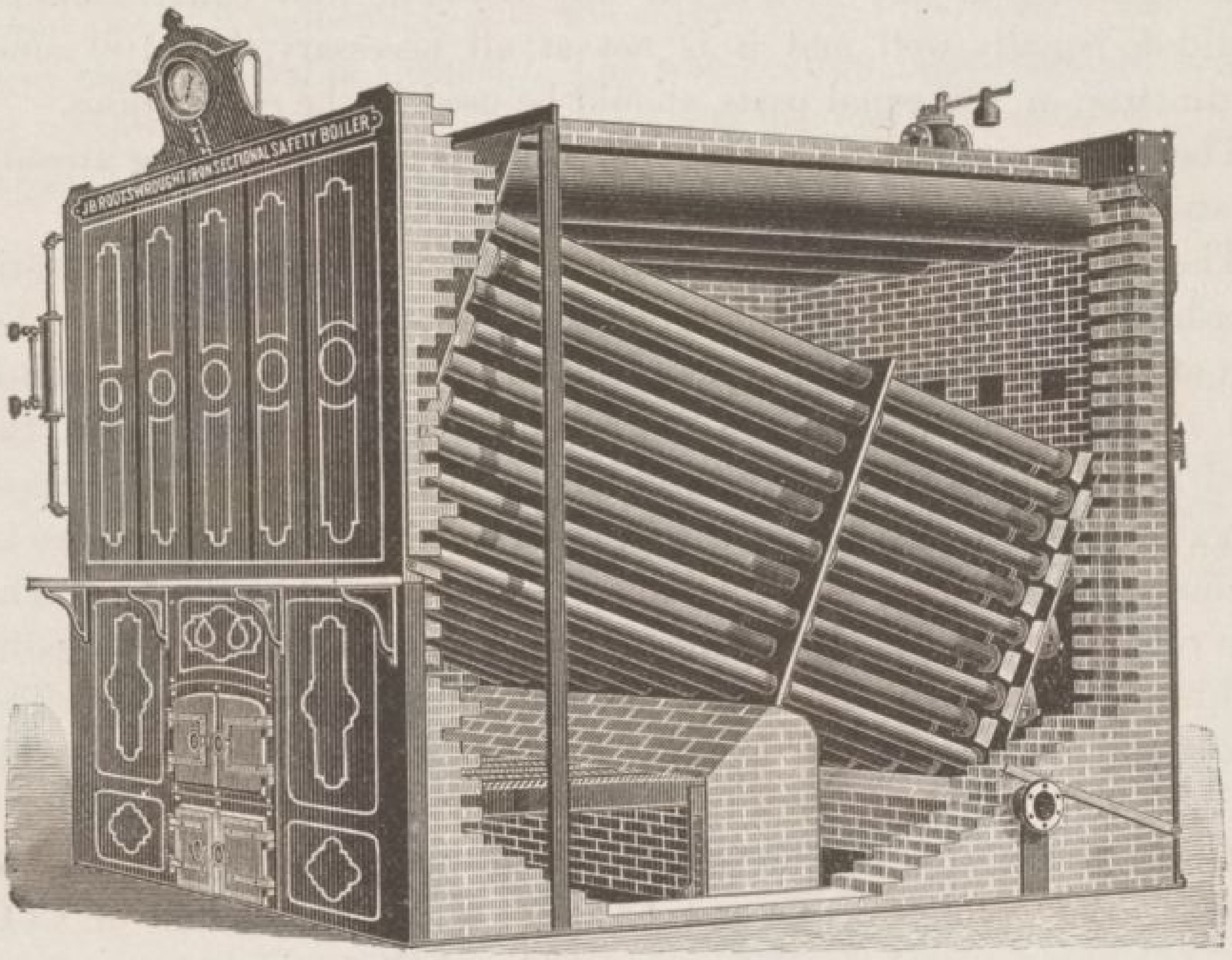

FIG. 6.

ROOT BOILER.

Before testing this boiler, (Fig. 6,) the back was boarded up. No other preparations were made for the test except cleaning the boiler the day before.

Ordinary care was taken with the fires, and the boiler was treated as in ordinary use.

Fires were started at 2.15 A.M., October 2, and as soon as the pressure of steam to be carried was reached, fires were hauled, and again started at 3.25 A.M., with a weighed quantity of wood and coal. At 3.25 P.M., October 3, fires were hauled and the test concluded.

BOILER MADE BY ABENROTH & ROOT MANUFACTURING COMPANY.

Rated horse-power 150.
Area heating surface.
  Having water on one side = 1440 square feet.
  Having steam on one side = 360 square feet.
    Total = 1800 square feet.
Area of grate = 50 square feet.
Steam space (approximate) = 76·5 cubic feet.
Height of smoke stack = 44 feet 6 inches.
Size of stack = 30 by 30 inches.
Time of test = 36 hours.
Water evaporated in boiler = 134937·3 pounds.
Mean temperature of feed water = 71·6 degrees F.
Total weight of wood used = 291·5 pounds.
Total weight of coal used = 18021·5 pounds.
Total weight of ashes = 2666·75 pounds.
Percentage of carbon in coal = 75·52.
Mean temperature of air during test = 57·0 degrees F.
Mean barometer = 30·323 inches.
Mean pressure in boiler = 91·41 pounds.
Mean temperature of steam = 341·32 degrees F.
Mean temperature of smoke stack = 369·92 degrees F.
Mean draft in chimney in inches of water = ·7.
Time during which blower was in use = 16 hours.
Mean pressure in boiler pipe = 1·16 inches.
Mean area of blower pipe open = 49·93 square inches.
Mean pounds of air per pound of carbon = 16·83.

The quality of steam from the calorimeter tests has not been determined, as the want of agreement in the two sets of tests make the results unsatisfactory.

The following gives the number of heat units in one pound of steam by both the apparatus shown in Fig. 3, and by using the plain barrel, and I would recommend that these results be entirely rejected, and the quality of the steam taken as from the temperature, which would make in this case 9·37° superheating.

The following table is from the calorimeter tests:

Time.	Total heat in 1 pound of steam from 32°F.	
	Apparatus of Fig. 3.	Barrel.
October 2, 2.57 P.M	1335·4	1185·5
" 3.57 "	1323·2	1290·1
" 4.57 "	1306·7	1272·5
" 5,57 "	1309·7	1192·8
" 7,57 "	1406·3	1367·8
" 9,57 "	1247·0	1485·5
" 11.57 "	1270·5	1047·2
October 3, 1.57 A.M	1282·5	1396·8
" 2,57 "	1344·6	1003·2
" 3,57 "	1285·7	1142·8
" 4,57 "	1281·8	1343·3
" 5.57 "	1335·0	1205·1
" 6,57 "	1250·4	1093·2
" 7.57 "	1216·4	1158·1
" 9,57 "	1256·4	1329·7
" 12,57 P.M	1268·8	1179·9
" 1.57 "	1296·7	1206·0
" 2,57 "	1313·9	1177·3

Calling one pound of wood equal to ·24 pound of coal in heating effect, the total equivalent weight of coal used is 70 + 18021·5 = 18091·5 pounds.

The percentage of ash is 14·74, while as shown from the analysis made it is 14·52 per cent.

The heat giving power of the fuel is determined as follows: There being 75·52 per cent. of carbon, and 2·18 per cent. of hydrogen exclusive of water, the equivalent percentage of carbon is 75·52 + 4·28 × 2·18 = 84·85 per cent., and the amount of carbon equivalent to the 18091·5 pounds of coal is ·8485 × 18091·5 = 15350·64 pounds of carbon.

To change one pound of water at 71·6° F. to steam at 341·32° F. requires 1186·04 — 39·6=1146·44 heat units. As it takes 966·07 heat units to change one pound of water at 212° F. to steam at 212; one pound of water from 71·6° to one pound of steam at 341·32° requires the same amount of heat as 1·1867 pounds from and at 212°.

Pounds of water evaporated per hour under the conditions...... = 3748·26
Pounds of water evaporated per hour from and at 212° F.......... = 4448·0
Pounds of coal used per hour.. = 468·87
Equivalent pounds of carbon used per hour............................... = 426·41
Horse-power of boiler (on the basis of 30 pounds of water from and at 212° per horse-power)... = 148·27
Pounds of water evaporated per pound of coal under the conditions.. = 7·9942
Pounds of water evaporated per pound of coal from and at 212°.. = 9·4866
Pounds of water evaporated per equivalent pound of carbon under the conditions... = 8·7903
Pounds of water evaporated per equivalent pound of carbon from and at 212° F... = 10·4313

Amount of air used in furnace per pound of coal $= \frac{16{\cdot}83}{{\cdot}7552} = 22{\cdot}29$ pounds.

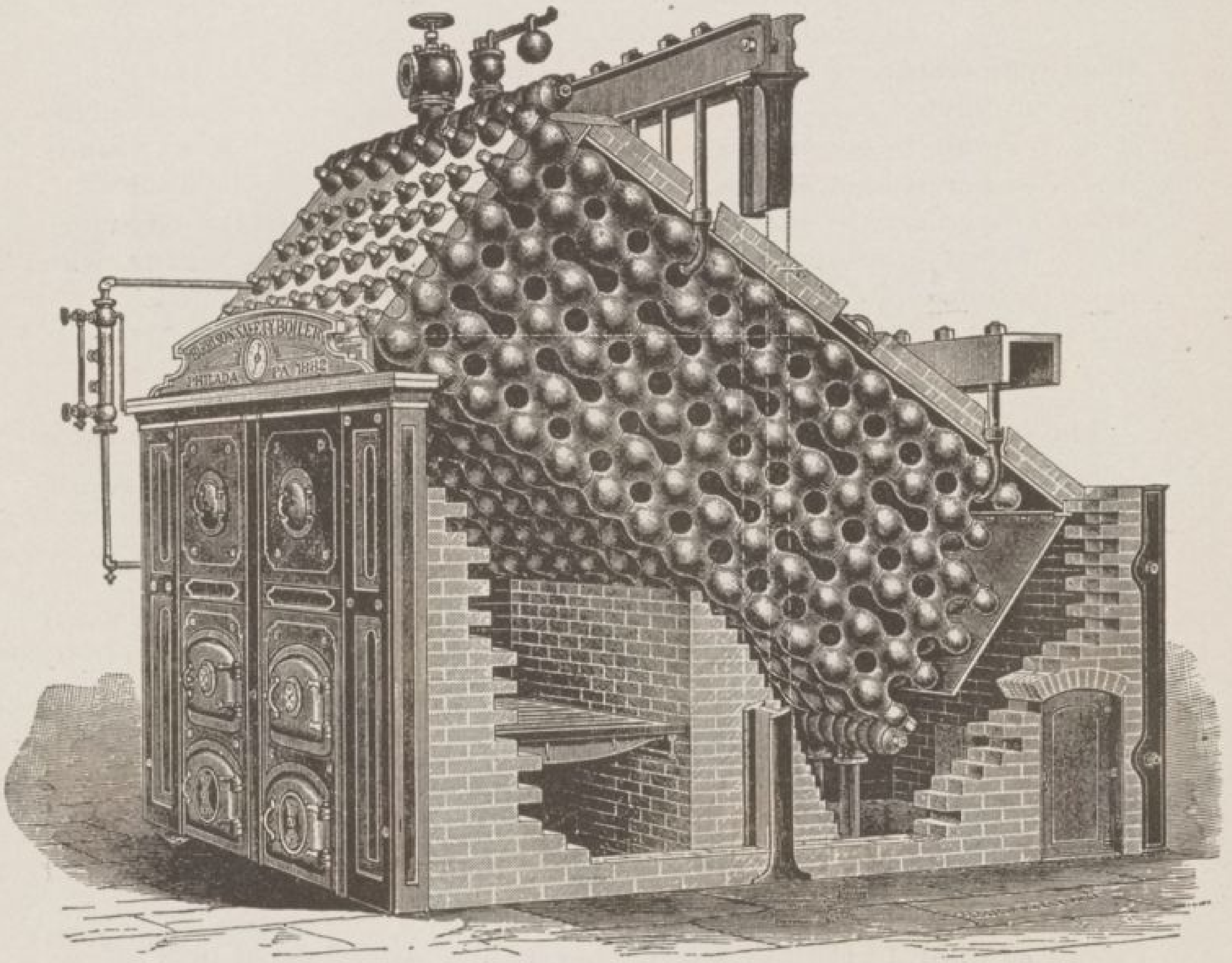

FIG. 7.

HARRISON BOILER.

The test began at 11.25 A. M., October 9, 1884, in the same manner as described for the Root test. At 12.57 P. M., October 10, cleaned boiler by means of steam nozzle, and at 11.25 P. M., October 10, fires were hauled and the test concluded.

Rating of boilers, manufacturers	100 horse-power
Water heating surface	948·54 sq. feet.
Steam " "	348·96 "
Total " "	1297·50 "
Steam room in boiler	29·8 cubic feet.
Grate surface	35·13 sq. feet.
Height of stack from ground	44 feet 6 in.
Size of pipe	30 × 30.
Water in boiler to steaming level	4878 pounds.
Time of test	36 hours.
Total weight of water evaporated in boiler	92606·75 pounds.
Mean temperature of water	68·77° F.
Total weight of wood used	348·5 pounds.
" " coal "	11725·75 "
" " ashes	1475·75 "
Percentage of carbon in coal	75·21
" " hydrogen "	1·82
Mean temperature of air during test	57·84° F.
Mean barometer	30·253 inches.
Mean pressure in boiler	95·83 pounds.
Mean temperature of steam	337·16° F.
Mean temperature of smoke-pipe	411·03° F.
Mean draft in chimney	·24 in. water.

Mean pounds of air per pound of carbon = 15·09.

QUALITY OF STEAM.

The quality of the steam was determined both by the Barrus calorimeter and the apparatus shown in Fig. 3, with the following results:

BARRUS CALORIMETER.

From 5.40 P. M. to 7.40 P. M., October 9...steam contains 7·4 per ct. water.
From 7.40 P. M. to 9.40 P. M., October 9..... " " 7·0 " "
From 9.40 P. M. to 11.40 P. M., October 9.... " superheated 63°
From 1.25 A. M. to 4.20 A. M., October 10...steam contains 3·4 per ct. water.
From 4.20 A. M. to 11.30 A. M., October 10.. " " 3·5 " "
From 11.30 A. M. to 1.25 P. M., October 10.. " " 2·1 " "
From 2.40 P. M. to 4.45 P. M., October 10... " " 0·11 " "
From 4.50 P. M. to 6.45 P. M., October 10.... " " 2·8 " "
From 6.50 P. M. to 8.55 P. M., October 10... " " 4·5 " "
From 9.45 P. M. to 11.20 P. M., October 10.. " superheated 168°.

From the apparatus shown in Fig. 3, we have the following results:

1.00 P. M., October 9 ....steam superheated 68°.
2.00 P. M., October 9 (a)...................... " " beyond limits of tables.
4.00 P. M., October 9.......................... " contains 13·1 per cent. water.
5.00 P. M., October 9.......................... " " 5·3 " "
6.00, 9 00, 10.00, 11.00, 12.00....................same as (a).

7.00	steam contains 30·7 per cent. water.
1.00 A. M., October 10	same as (a).
3.00 A. M., October 10	steam superheated 57°.
5.00, 6.00 A. M., October 10	same as (a).
7.00 A. M., October 10	steam contains 7·7 per cent. water.
8.00 A. M., October 10	" superheated 57°.
9.00, 10.00, 11.00, 12.00, October 10.	same as (a).
1.00 P. M., October 10	same as (a).
3.00, 4.00, 5.00, 6.00, October 10	same as (a).
7.00 P. M , October 10	steam superheated 70°.
9.00, 10.00 and 11.00 P. M., October 10	same as (a).

While the results given from the Barrus calorimeter show a reasonable agreement, it is doubtful whether the results are a fair measure of the quality of the steam produced, as the thermometer in the steam space shows 337·16° F., while the temperature corresponding to the steam pressure 95·83 pounds is 334·93° F. The difference, or 2·23°, shows that the average quality of the steam was dry or superheated 2·23° F., and in the succeeding deductions this value will be taken in calculating the relative weight of water evaporated per pound of coal.

As before, assuming that one pound of wood = ·24 pounds of coal, the total equivalent weight of coal used is $348·5 \times ·24 + 11725·75 =$ 11809·39 pounds. The percentage of ash is $\frac{1475·75}{11809·39} = 12·5$ per cent., while the analysis made shows 14·03 per cent.

The heat giving power of the fuel is determined as follows: there being 75·21 per cent. of carbon and 1·82 per cent. of hydrogen, exclusive of water, the equivalent percentage of carbon is $75·21 + 1·82 \times 4·28 =$ 83·00 per cent., and the equivalent amount of carbon in the 11809·39 pounds of coal is $11809·39 \times ·83 = 9801·79$ pounds.

To change one pound of water at 68·77° F. into steam at 337·16° F. requires $1184·77 - 36·77 = 1148·00$ heat units. As it takes 966·07 heat units to change one pound of water at 212° into steam, at 212°, one pound of water from 68·77° to steam at 337·16° requires the same amount of heat as 1·1883 pounds of water from and at 212°.

Pounds of water evaporated per hour under the conditions	= 2572·41
Pounds of water evaporated per hour from and at 212°	= 3056·79
Pounds of coal used per hour	= 328·04
Equivalent pounds of carbon used per hour	= 272·27
Horse-power of boiler on the basis of 30 pounds of water from and at 212° per horse-power	= 101·89

Pounds of water evaporated per pound of coal underthe conditions .... = 7·8417
Pounds of water evaporated per pound of coal from and at 212°.. = 9·3183
Pounds of water evaporated per equivalent pound of carbon under the conditions .... = 9·4480
Pounds of water evaporated per equivalent pound of carbon from and at 212°.. .... = 11·2270

Amount of air used in furnace per pound of coal $\frac{15·09}{·7521}$ = 20·06 pounds.

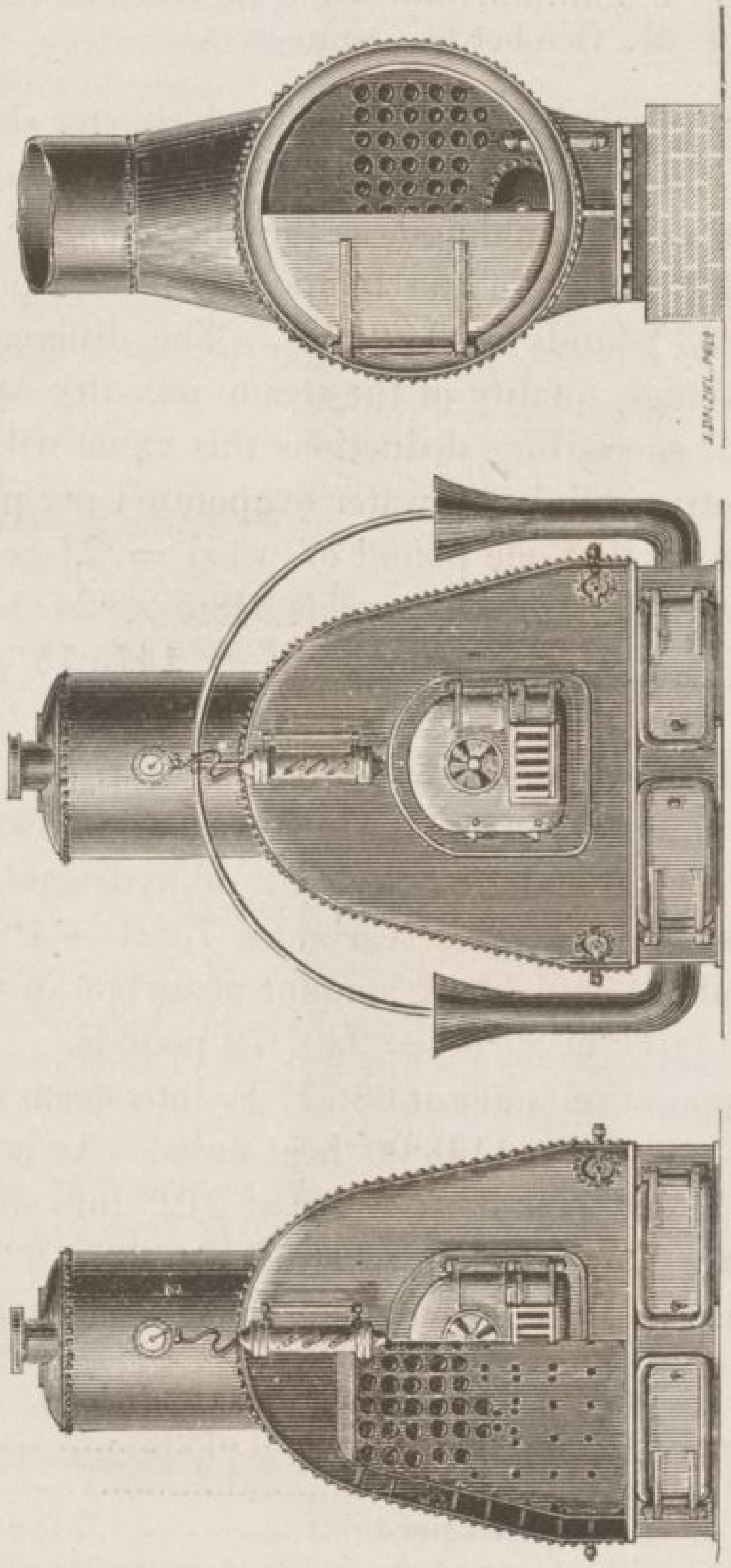

FIG. 8.

DICKSON BOILER.

This boiler, Figs. 8 and 9, is manufactured by the Dickson Manufacturing Company, of Scranton, Pennsylvania. It is a horizontal tubular boiler having 68, 3 inch tubes, each 15 feet long. It has a spread fire box wider at the top than at the bottom. The grate used was of the Howe pattern, 6 feet 6 inches by 4 feet 10 inches. The shell is cylindrical 50 inches in diameter and is 34½ feet long. The steam dome is 30 inches by 30 inches.

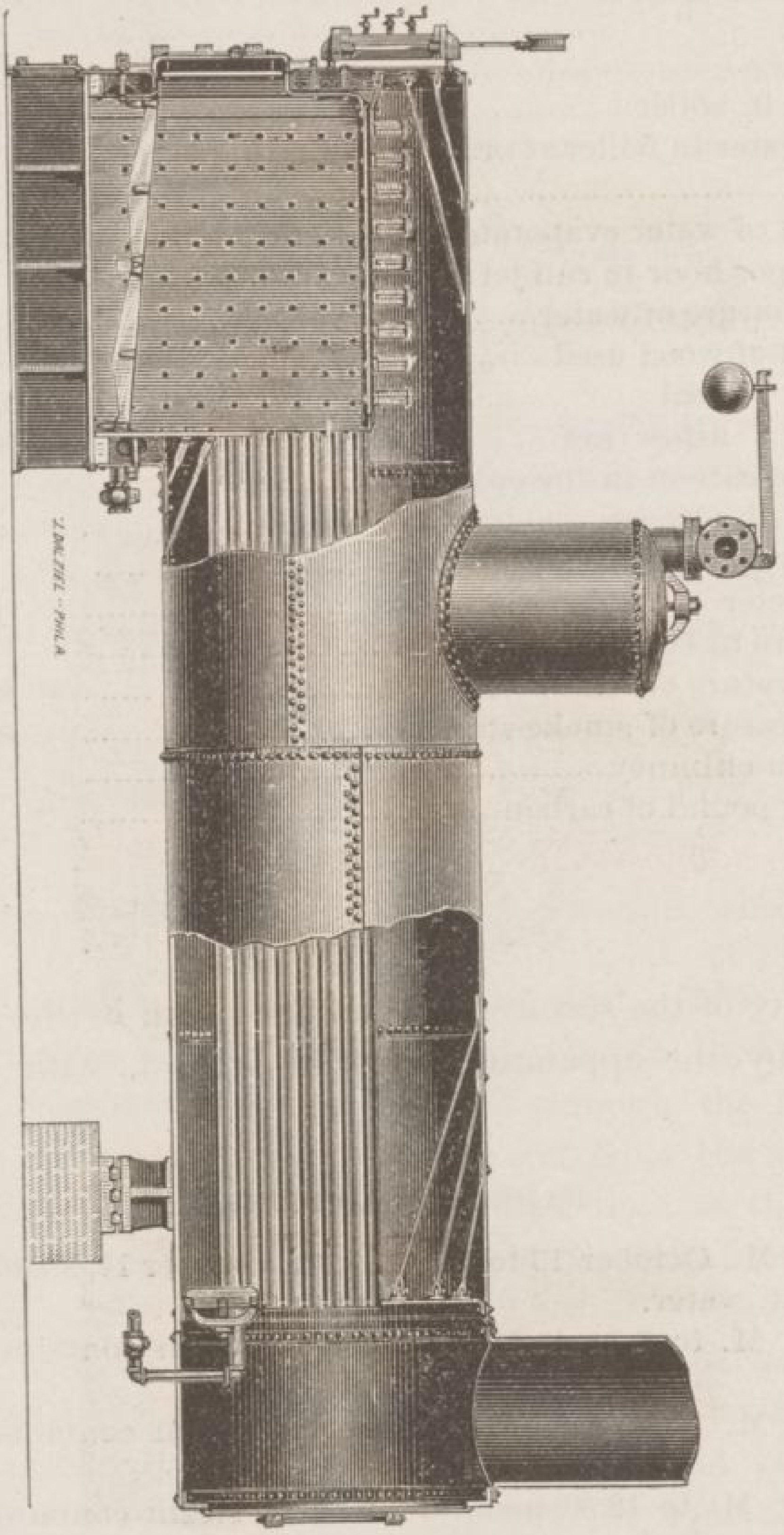

FIG. 9.

Rating of boiler, manufacturers = 76 horse-power. Before beginning this test the boiler was thoroughly protected by means of a one-inch layer of felt over the entire boiler, excepting the front head. The test began at 6.31 P. M., October 13, 1884, and ended at 6.31 A. M., October 15.

The boiler was designed to burn culm, but as none could be procured in time for the test, screenings from pea coal were used instead.

Water heating surface.................................... = 841· sq. feet.
Steam " " .... = 2·5 "
Total " " .... = 843·5 "
Grate surface.................................... = 31·41 "
Steam space in boiler.................................... = 67 cubic ft.
Weight of water in boiler at ordinary standing level... = 10200 pounds.
Time of test.................................... = 36 hours.
Total weight of water evaporated in boilers.................. = 137152·75 pounds.
Water used per hour to run jet.................................... = 472·5 "
Mean temperature of water.................................... = 67·17° F.
Total weight of wood used.................................... = 232·5 pounds.
" " coal " .... = 20026 50 "
" " ashes (net).................................... = 5048·37 "
Percentage of carbon in the coal.................................... = 72·87
" hydrogen (exclusive of water).................. = 2·53
Mean temperature of air.................................... = 50·26° F.
Mean barometer.................................... = 30·299 inches.
Mean pressure in boiler.................................... = 83·54 pounds.
Mean temperature of steam.................................... = 326·19° F.
Mean temperature of smoke-stack.................................... = 422·72° F.
Mean draft in chimney.................................... = ·15 inches.
Mean air per pound of carbon.................................... = 13·66 pounds.

QUALITY OF STEAM.

The quality of the steam was determined both by the Barrus calorimeter and by the apparatus shown in Fig. 3, with the following results:

BARRUS CALORIMETER.

From 7.20 P. M., October 13 to 11.20 A. M., October 14, steam contains 0·78 per cent. water.

From 1.20 A. M. to 3.20 A. M., October 14, steam contains 2·7 per cent. water.

From 3.20 A. M. to 5.20 A. M., October 14, steam contains 1·9 per cent. water.

From 5.20 A. M. to 12.00 noon, October 14, steam contains 2·5 per cent. water.

From 12.00 noon to 2.00 P. M., October 14, steam contains 7·6 per cent. water.

From 2.00 P. M. to 4.00 P. M., October 14, steam superheated 22°.

From 4.00 P. M. to 6.00 P. M., October 14, steam superheated 7°.
From 6.00 P. M. to 8.00 P. M., October 14, steam contains 1·2 per cent. water.
From 8.00 P. M. to 10.00 P. M., October 14, steam contains 3·8 per cent. water.
From 10.00 P. M. to 12.00 midnight, October 14, steam contains 2·6 per cent. water.
From 10.00 midnight to 2.00 A. M., October 15, steam contains 0·8 per cent. water.
From 2.00 A. M., October 15 to 4.00 A. M., October 15, steam contains 1·7 per cent. water.
From 4.00 A. M., October 15 to 6.00 A. M., October 15, steam contains 1·2 per cent. of water.

The results from the apparatus shown in Fig. 3 were totally unreliable, giving in every case highly superheated steam of 400° or over.

As the temperature of the steam almost exactly corresponds with the temperature corresponding to the pressure, it is evident that the steam must have been either saturated or wet, and taking the results from the Barrus apparatus as correct, we have for a mean 1·55 per cent. of moisture in the steam, and this value will be taken in the succeeding deductions.

As before, assuming that one pound of wood = ·24 pounds of coal, the total equivalent weight of coal used is $232{\cdot}5 \times {\cdot}24 + 20026{\cdot}50 =$ 20082·3 pounds.

The percentage of ash is $\frac{5048{\cdot}37}{20082{\cdot}3} = 25{\cdot}1$ per cent., while the analysis of the coal made shows but 10·39 per cent. This discrepancy may be accounted for in the following way: the coal used was siftings from pea coal, considerable of which fell through the grate partly burned, and as the ashes were continually wet from the steam jet, no attempt was made to burn the refuse a second time, as the loss from the wet ashes would probably be more than the gain from more perfect combustion.

The equivalent weight of carbon used was determined as in the case of the preceding boilers. The percentage of carbon being 72·87 and of hydrogen (exclusive of water) 2·53, the equivalent percentage of carbon is $72{\cdot}87 + 4{\cdot}28 \times 2{\cdot}53 = 83{\cdot}70$; and the equivalent amount of carbon in the 20082·3 pounds of coal is 16808·89 pounds.

To change one pound of water at 67·17° into steam 83·54 pounds pressure and containing 1·55 per cent. of moisture requires 1167·78

— 35·17 = 1132·61 heat units. As it takes 966·07 heat units to change one pound of water at 212° into dry steam at 212°, one pound of water under the conditions of this test requires the same amount of heat as 1·1724 pounds of water from and at 212°.

As the total weight of water evaporated is 137152·75 pounds, and as 472·5 pounds of water are used per hour to run the jet, the amount of water available for use outside the boiler, or the proper quantity of water which should be credited to the boiler is 137152·75 — 36 × 472·5 = 135451·75 pounds.

Pounds of water evaporated per hour under the conditions....... = 3762·55
Pounds of water evaporated per hour from and at 212°.............. = 4411·21
Pounds of coal used per hour... = 557·84
Equivalent pounds of carbon used per hour................................ = 466·91
Horse-power of boiler (on basis of 30 pounds of water from and at 212° per horse-power)... = 147·04
Pounds of water evaporated per pound of coal under the conditions.. = 6.7449
Pounds of water evaporated per pound of coal from and at 212° = 7·9076
Pounds of water evaporated per equivalent pound of carbon, under the conditions.. = 8·0584
Pounds of water evaporated per equivalent pound of carbon from and at 212°... = 9·4477

Amount of air used in furnace per pound of coal $= \frac{13{\cdot}66}{{\cdot}7287} =$ 18·74 pounds.

BALDWIN BOILER.

An attempt to test this boiler was made on September 29, 1884, and after continuing for 24 hours, the fires became very low because of the coal having so much clinker, requiring that the fires should be constantly cleaned, and the test was stopped.

At the request of the company exhibiting the boiler, a second test was made beginning at 1.19 P. M., October 24, 1884, and ending at 1.19 P. M., October 25, 1884, and the results of this test alone are given in this report.

This boiler was made by the Baldwin locomotive works. It is a horizontal cylindrical flue boiler, sixteen feet long, of 54 inches diameter, and having 4-inch flues. The bottom of the boiler was set 34 inches above the grate.

Over the boiler is placed a steam drum twenty-four inches in diameter and eight feet long, connected to the boiler by means of one neck 12 inches in diameter and 10 inches long.

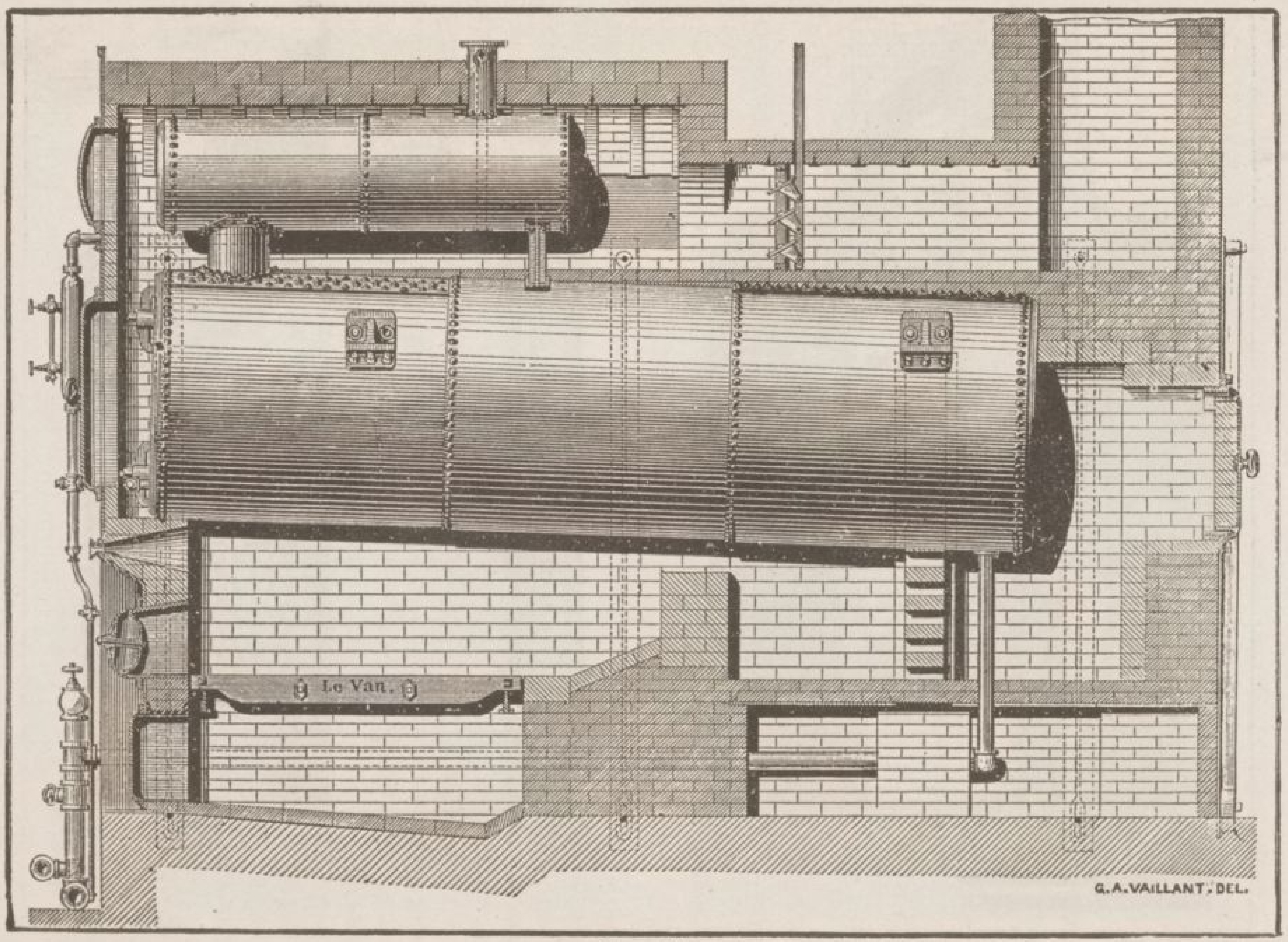
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FIG. 10.

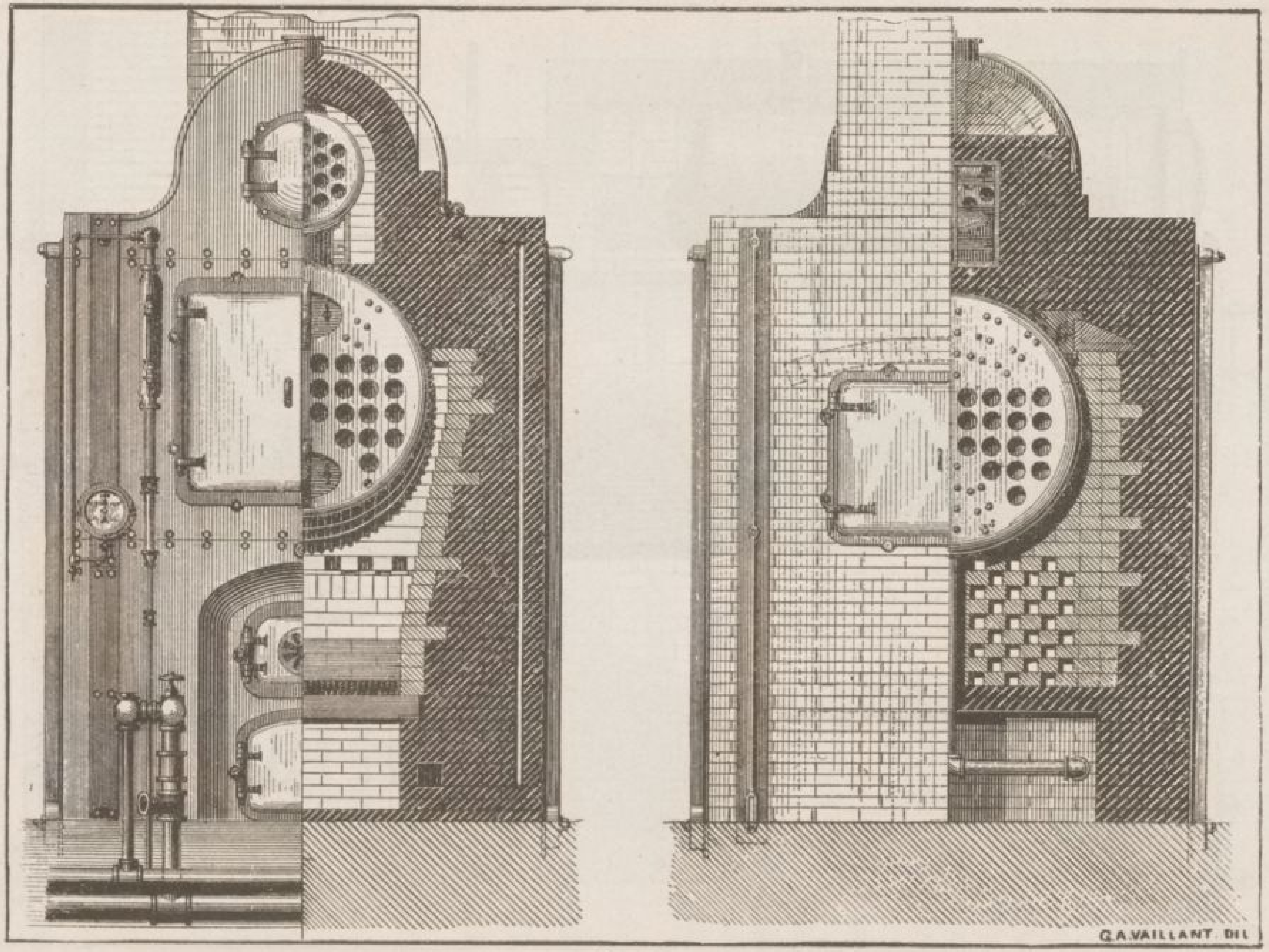
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FIG. 11.

Rating of boiler	50 horse-power.
Grate surface	21 square feet.
Heating surface, total	799·62 sq. feet.
" " wetted	663·31 sq. feet.
" " steam	136·31 sq. feet.
Grate 42 inches by 72 inches.	
Chimney 30 inches by 30 inches.	
Height of chimney	44 feet 6 inches.
Time of test	24 hours.
Total weight of water evaporated in boiler	38108·0 pounds.
Mean temperature of water =	59·91° F.
Total weight of wood used =	191·5 pounds.
Total weight of coal used =	6031·0 "
Total weight of ashes =	654·25 "
Percentage of carbon in coal =	80·22
Percentage of hydrogen (exclusive of water) =	2·53
Mean temperature of air during test =	45·25° F.
Mean barometer =	30·274 inches.
Mean pressure in boiler =	98·71 pounds.
Mean temperature of steam =	343·78° F.
Mean temperature of smoke stack =	346·85° F.
Mean draft in chimney =	·243 inches.
Mean air per pound of carbon =	16·24 pounds.

QUALITY OF STEAM.

The quality of the steam was determined only by the Barrus calorimeter with the following results:

From 2.50 P. M., October 24, to 4.20 P. M. October 24, steam contains 0·78 per cent. water.

From 4.20 P. M., October 24, to 6.20 P. M., October 24, steam contains 1·8 per cent. water.

From 6.20 P. M., October 24, to 8.20 P. M., October 24, steam contains 1·9 per cent. water.

From 8.20 P. M., October 24, to 10.20 P. M., October 24, steam is dry.

From 10.20 P. M., October 24, to 12.20 A. M., October 25, steam contains 2·8 per cent. water.

From 2.20 A. M., October 25, to 4.20 A. M., October 25, superheated 174°.

From 4.20 A. M., October 25, to 6.20 A. M., October 25, contains 3·9 per cent. water.

From 8.40 A. M., October 25, to 12.20 P. M., October 25, contains 23.5 per cent. water.

The mean of these results is 6·95 per cent. of moisture in the steam. The temperature of the steam by thermometer is 343·78° F., and the temperature corresponding to the pressure 98·71 pounds per gauge is 336·83° F., and the average quality of the steam from the temperature is 6·95° superheated. Assuming that this latter value is more correct than the one given by the Barrus calorimeter, this value will be used in the following deductions.

As before, assuming that one pound of wood = ·24 pounds of coal, the total equivalent weight of coal used is 6031 + 191·5 × ·24 = 6076·96 pounds.

The percentage of ash is $\frac{654.25}{6076\cdot96}$ = 10·76 per cent., while the analysis made shows 10·39 per cent.

The equivalent weight of carbon used was determined as in the cases of the preceding boilers. The percentage of carbon being 80·22, and of hydrogen (exclusive of water) 2·53 per cent, the equivalent percentage of carbon is 80·22 + 4·28 × 2·53 = 91·05 per cent., and the equivalent amount of carbon in 6076·96 pounds of coal is = 5533·07 pounds.

To change one pound of water at 59·91° into steam of 98·71 pounds pressure and 6·95° superheated, requires 1186·791 — 27·91 = 1158·881 heat units. As it takes 966·07 heat units to change one pound of water at 212° into steam at 212°, one pound of water under the conditions of this test requires the same amount of heat as 1·1996 pounds of water from and at 212°.

Pounds of water evaporated per hour, under the conditions...... =	1587·83
Pounds of water evaporated per hour, from and at 212°............ =	1904·76
Pounds of coal used per hour.. =	253·21
Equivalent pounds of carbon used per hour............................... =	230·54
Horse-power of the boiler (on the basis of 30 pounds of water from and at 212° per hour, horse-power)................................ =	63·49
Pounds of water evaporated per pound of coal, under the conditions.. =	6·2708
Pounds of water evaporated per pound of coal from and at 212° =	7·5224
Pounds of water evaporated per equivalent pound of carbon, under the conditions..	6·8874
Pounds of water evaporated per equivalent pound of carbon, from and at 212°..	8·2621
Amount of air used in the furnace per pound of coal................	20.24 lbs.

Resumé of Results obtained in Boiler Tests.

Name of Boiler on Trial.	Root.	Harrison.	Dickson.	Baldwin.
Date of Trial.	Oct. 2, 1884.	Oct. 9.	Oct. 13.	Oct. 24.
Duration of trial in hours	36	36	36	24
Rated horse-power by makers	150	100	76	50
Developed horse-power in test assuming 30 pounds of water from and at 212 degrees per horse-power	148·27	101·89	147·04	63·49
Water heating surface in square feet	1440	948·54	841	663·31
Steam heating surface in square feet	360	348·96	2·50	136·31
Total heating surface in square feet	1800	1297·5	843·50	799·62
Grate surface in square feet	50	35·13	31·41	21
Ratio of grate to heating surface	1 : 36	1 : 37	1 : 26·8	1 : 38
Height of chimney, in feet, from grate	44·5	44·5	28·6	44·5
Average steam pressure in pounds per square inch	91·41	95·83	83·54	98·71
Barometer in inches	30·323	30·253	30·299	30·274
TEMPERATURES, FAHRENHEIT.				
Average temperature of the air (Fah.)	57	57·84	50·26	45·25
Average temp. of the steam in boilers	341·32	337·16	326·19	343·78
Temperature corresponding to average boiler pressure	331·95	334·93	326·36	336·83
Average temperature of the chimney	369·92	411·03	422·72	346·85
Average temperature of the feed-water	71·6	68·77	67·17	59·91

Resumé of Results obtained in Boiler Tests.—Continued.

Name of Boiler on Trial.	Root.	Harrison.	Dickson.	Baldwin
Date of Trial.	Oct. 2, 1884,	Oct. 9.	Oct. 13.	Oct. 24.
COAL AND ASHES.				
Pounds of wood used	291·5	348·5	232·5	191·5
Pounds of coal used	18021·5	11725·75	20026·5	6031
Pounds of coal and wood, including value of latter	18091·5	11809·39	20082·3	6076·96
Pounds of ashes	2666·75	1475·75	5048·37	654·25
Pounds of carbon	15350·64	9801·79	16808·8	5533·07
Pounds of carbon per hour	426·41	272·27	466·9	230·54
Pounds of coal per hour	468·87	328·04	557·84	253·21
WATER.				
Pounds of water feed in the boiler at average temperature above given	134937·3	92606·75	137152·75	38108
Pounds of water evaporated per hour from and at 212°	4448	3056·79	4411·21	1587·83
Pounds of water evaporated per pound of coal	7·99	7·84	6·75	6·27
Pounds of water evaporated per pound of carbon from and at 212°	10·43	11·23	9·45	8·26
Quality of steam by thermometer, or amount of superheating	9·37	2·23	....	6·95
Percentage of moisture	....	....	1·55	....
RATE OF COMBUSTION.				
Pounds of coal burnt per square foot of grate per hour	10	9·3	18	12
Pounds of water per square foot of grate per hour	87	89	140	76
Pounds of water per square foot of heating surface per hour	2·3	2·5	5.2	2
DRAFT.	Blower.	Natural.	Steam Jet.	Natural.
Mean draft in chimney in inches	0·7	·24	·15	.43
Steam room in boiler in cubic feet	7·65 ap.	29·8	67	....

At the meeting of the Examiners of Section X, held at the Franklin Institute, March 23, 1885, the following resolution was adopted : *

Resolved, That the report of Mr. Spangler be adopted as rendered, and that the same be published in its entirety, with the addition of a tabulated resumé of the results. That the committee refrain from criticism of the boilers as prescribed by the Code, excepting upon the points of economy of fuel and evaporated efficiency, as contained in report adopted. That all accuracy of the calorimetrical measurements be disclaimed, but all data referring thereto be printed, as evidence of work performed in the attempt to obtain reliable results.

WM. D. MARKS,	ARTHUR L. CHURCH,
W. BARNET LE VAN,	FRED'K GRAFF,
C. CHABOT,	CHAS. E. RONALDSON,
A. B. WYCKOFF.	OTTO C. WOLF,
	Committee present.

Members of Section X.—Gould H. Bull, C. Chabot, R. E. Crawford, J. E. Denton, Charles H. Fisher, Carl Hering, Washington Jones, Gaetano Lanza, W. Barnet Le Van, William Ludlow, William D. Marks, O. E. Michaelis, John Milliss, John W. Nystrom, T. W. Rae, Charles E. Ronaldson, H. W. Spangler, Otto C. Wolf, A. B. Wyckoff.

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*This report has, according to the directions of the Board of Managers of the Franklin Institute, been edited and supervised by the Committee appointed for that purpose. The language of this resolution must not be interpreted to imply that any exception was made to the mode of printing the reports.

PERSIFOR FRAZER,
WM. H. WAHL,
Executive Committee of Editing Committee.

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1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

REPORT OF EXAMINERS
OF
SECTION XI.

8334

STEAM ENGINES.

Philadelphia.

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

OF THE

FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

REPORTS OF THE EXAMINERS

OF

SECTION XI.

(SECTION I, CLASS VI OF THE CATALOGUE.)

STEAM ENGINES.

[ISSUED BY AUTHORITY OF THE BOARD OF MANAGERS AND PUBLISHED AS A
SUPPLEMENT TO THE JOURNAL OF THE FRANKLIN
INSTITUTE, FEBRUARY, 1886.]

PHILADELPHIA:
THE FRANKLIN INSTITUTE.
1886.

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1884-INTERNATIONAL ELECTRICAL EXHIBITION-1884

FRANKLIN INSTITUTE, Philadelphia, Pa.

REPORT OF EXAMINERS.

SECTION XI.—STEAM ENGINES.

To the Board of Managers of the FRANKLIN INSTITUTE:

GENTLEMEN:—I have the honor to transmit herewith the report of Examiners of Section XI, on "Steam Engines."

Respectfully,

M. B. SNYDER,
Chairman Board of Examiners.

PHILADELPHIA, November, 1885.

Chairman Board of Examiners, International Electrical Exhibition:

SIR:—I herewith hand you the report of Section XI, on "Steam Engines."

Respectfully,

WM. D. MARKS.
Chairman Section XI.

REPORT OF EXAMINERS. SECTION XI. STEAM ENGINES.

Code of the Quantitative Tests Proposed for the Steam Engines, at the International Electrical Exhibition of 1884, of the FRANKLIN INSTITUTE, *of the State of Pennsylvania.*

SPECIAL NOTICE.

Parties exhibiting engines who may desire quantitative tests made of them, must make formal application for such tests before July 15, 1884.

Engines can be exhibited, but will not be tested unless formal application and agreement to the code are completed within the specified time.

Parties desiring to have tests made of their engines, can have them made by so signifying and by subscribing to and fulfilling the conditions of the Code.

All tests will be quantitative, and will not be abridged, save by special agreement with the judges.

Tests of regularity of speed will, however, be made independently of other measurements.

The Committee reserves the right to limit the number of engines tested, and to elect which engines shall be tested, if time will not permit complete tests of all.

Competitive tests will not be made, save on the joint application of the two or more parties desiring them, who must agree on the rating of the various points of the engines (See Article 9) previous to the tests, and subscribe in the Code, agreeing to abide by the decision of the Judges without appeal.

SECTION I.

CONDITIONS OF EXHIBITION AND TEST.

ARTICLE 1. Cylinders.

The cylinders of the engines entered may be of any capacity and proportion of stroke to diameter.

ARTICLE 2. Indicator Connections.

Each cylinder shall be drilled and tapped by the builder for indicator connections, by means of one-half inch pipe, in the usual manner, and to the satisfaction of the judges. Pet drainage cocks must be on the cylinder. The cross head, or other moving part, must be drilled for the indicator cord attachment.

ARTICLE 3. Clearance.

Each cylinder shall be drilled and plugged at both ends, so as to admit of being completely filled with water and emptied by means of a one-half inch pipe, in order to determine the clearance and the piston displacement of one stroke at each end. These data will be obtained both hot and cold.

ARTICLE 4. Valves.

The steam and exhaust valves will be tested under full steam pressure, ninety (90) pounds per square inch by the gauge, unless some other pressure has been agreed upon for the test.

Article 5. Piston Packing.

The tightness of the piston packing will be determined by removing the back cylinder heads, and subjecting the piston to full boiler pressure on each centre.

Article 6. Fly Wheel.

Each maker is requested to use such diameter of band fly wheel, or of pulley, as shall give a belt speed of 4,000 feet per minute.

Should he require a different belt speed, he will specially note the same in communicating with the Exhibition Committee.

Article 7. Steam Pipes.

Each exhibitor will be required to furnish his own connection with the main steam pipe, the main injection pipe, and the main overflow pipe or tanks.

Article 8. Space.

Each exhibitor will be furnished with space at the regular rates established for the Exhibition, in which space he must build his foundations at his own cost, and subject to the approval of the Superintendent.

Article 9. Specifications.

Each exhibitor will communicate to the Chairman of the Committee of Judges on Steam Engines, such description and drawings of the engine exhibited as will facilitate the labors of that Committee, together with his claims as to the meritorious points for his exhibit.

The Following Points will have Special Consideration.

(1.) Economy of steam.
(2.) Regularity of speed.
(3.) Concentration of power.
(4.) Durability of construction.
(5.) Simplicity of design.
(6.) Excellence of proportions.
(7.) Finish of parts.

Each exhibitor must file the following data:

Diameter of the steam cylinder to the nearest $\frac{1}{100}$ of an inch.
Diameter of the piston rod " " " " "
Diameter of the steam pipe " " " " "
Diameter of the exhaust pipe " " " " "
Diameter of the band, or fly wheel " " " " "
Width of the face, or fly wheel " " " " "
Weight of the fly wheel in pounds.
Area of the steam ports each to the nearest $\frac{1}{100}$ of an inch.
Area of the exhaust ports each " " " " "
Stroke of the engine " " " " "
Indicated horse-power of the engine when working most economically.
Revolutions of the crank per minute.
Weight of the whole engine, exclusive only of the fly wheel.

If a condenser is used and driven by the engine.
Diameter of the air-pumps to the nearest $\frac{1}{100}$ of an inch.
Diameter of the injection pipe " " " " "
Diameter of the overflow pipe " " " " "
Stroke of the air-pump piston " " " " "
If an independent condenser is used, that is not driven by the engine.
Diameter of the injection pipe, to the nearest $\frac{1}{100}$ of an inch.
Diameter of the overflow pipe " " " " "

Drawings of the condenser used, any other data peculiar to it, and a full description of it.

SECTION II.

PREPARATIONS FOR THE TEST.

Article 10. Steam.

The steam for the tests will be furnished by the exhibition boilers, and will come from boilers specially set apart for the purpose of the tests. It will be charged for at regular rate of three (3) cents per indicated horse-power per hour. Steam, if desired, will be furnished to exhibitors one week before the tests are made.

No charge will be made for the services of attendants or experts, or the use of apparatus, unless in some extraordinary case, when the cost will be fixed by the Superintendent of the Exhibition. No charge against the engine will be made for steam when its power is ordered by the Superintendent for the other purposes of the Exhibition.

Article 11. Pressure.

The steam pressure used will be subject to the wish of the exhibitor, but shall not exceed ninety (90) pounds per square inch, by the gauge.

A special standard gauge will be used during the test, and subjected to careful tests before and after use.

Article 12. Safety valve.

The safety valve will be set to blow off at ten (10) pounds above the pressure fixed upon.

Article 13. Quality of the Steam.

The thermal value, the temperature and the pressure will be taken by means of scale calorimeters, thermometers and standard gauges at the boiler, at the steam chest, and at the exhaust, if the engine is non-condensing.

The thermometers, calorimeters, etc., will be furnished by the Exhibition, but the exhibitor must do such mechanical work, must furnish such piping, tools and materials as are necessary to make the required attachments, at his own cost, and subject to the orders of the Committee of Judges.

Article 14. Temperature.

The temperatures of injections and of hot well, will be taken with standard thermometers in the case of condensing engines.

ARTICLE 15. Water.

The water used will be taken from the city mains.

The feed water for the boilers will be weighed by means of scales, and a large tank, and will be run into a smaller supplemental tank, from which it will be pumped into the test boilers by means of a feed-pump, actuated by steam from other boilers.

The condensing water used will, in the case of condensing engines, be measured after leaving the hot well, in two carefully gauged tanks, alternately filled and emptied, the temperature also being taken.

The known weight of steam used will be subtracted from the overflow.

The injection water will be weighed in large tanks, and its temperature taken.

The injection water will not be delivered under pressure.

ARTICLE 16. Speed of Engine.

The number of revolutions of the engine will be taken by a continuous counter attached to the crank shaft.

The variations in speed for one minute will be taken at each quarter of an hour by means of an electric chronograph, connected with a standard clock beating seconds.

The variations in speed during one stroke will be taken by an acoustic chronograph at fifteen minutes interval.

Special tests of speed alone, under varying loads, will be made if desired, and close attention will be had to this point in all cases.

ARTICLE 17. Barometric Measurements.

A standard barometer and thermometer will be read at fifteen minutes interval during the trial.

ARTICLE 18. Vacuum.

The vacuum of condensing engines will be read by a gauge, carefully compared before and after the trials.

ARTICLE 19. Testing of Gauges, Indicators, etc.

All of the gauges, indicators and thermometers used, shall be carefully tested before and after the trials, and the party whose engine is tested, shall have the right to be present in person or by agent, at these tests.

ARTICLE 20. Diagrams.

The indicator diagrams will be taken at fifteen (15) minutes intervals, and will be read for:

Initial pressure,
Pressure at cut-off,
Terminal pressure,
Counter pressure at mid-stroke,
Maximum compression pressure,
Mean effective pressure,
Point of cut-off,
Release of steam,
Exhaust closure.

From the diagrams will be computed the indicated steam at the point of cut-off, and at release, as also the actual steam from boilers per horse-power per hour.

ARTICLE 21. Load of the Engine.

The Committee of Judges will test the engine at the load desired by the exhibitor of it, unless circumstances shall render it impossible to meet his wishes.

If the load does not exceed seventy-five (75) indicated horse-power, the net load will be measured by a Transmitting Dynamometer.

ARTICLE 22. Friction Diagrams.

At the close of the regular trial, the engine will have its belt taken off, and be run for one hour for friction diagrams.

ARTICLE 23. Duration of the Trials.

Unless otherwise arranged, the trials will last ten (10) hours.

ARTICLE 24. Economy and Efficiency of the Engine.

No account will be taken of the coal burned, but the economy of the engine will be deduced from the actual steam used and water weighed to the boiler.

The trial will begin with the established pressure.

The level of the water in the boiler, and the pressure of the steam will be kept as nearly constant, as possible, during the whole of the trial.

The whole weight of the water fed to the boiler, subject to proper deductions for waste, and to corrections for variation of level in the boiler, will be multiplied by its thermal value as steam at the steam-chest, and divided by the product of the indicated horse-power of the engine, and the number of hours of the test.

The resulting quotient will be used to divide twenty-five hundred and fifty-seven and sixty-nine one-hundreths (2557·69) British thermal units, giving the efficiency of the engine as compared with the mechanical equivalent of the heat furnished to it, and therefore its efficiency, as a means of converting heat into work.

The net horse-power of the engine will be used for computation similarly to the indicated horse-power, and the result will be taken as the measure of the efficiency of the engine, both as a means of converting heat into work, and as a machine for the transmission of power.

This latter shall be considered the true measure of the efficiency of the engine.

METHODS USED.

TIME OF TEST.

It was the intention that each of these tests should last exactly ten (10) hours. But in the case of the Porter-Allen engine, the engine was stopped to change indicator, and in the case of the Southwark engine, the test lasted eleven (11) hours and two (2) minutes.

STEAM.

The steam used in the engine tests was taken from a boiler which was not in use for any other purpose, and had all valves connecting with other boilers and engines tightly closed. It was not practicable that the steam pipe should be run directly from the boiler used to the engine tested, and in the cases of the Southwark and Porter-Allen engines the steam pipe was very long, and had a number of pockets, in which steam and condensed water lodged. The engines were in all cases run for a considerable time before the tests began, and an endeavor was made to leave the boiler, engine and all their attachments at the end of the test in the same condition as at the beginning.

Before beginning the tests, the level of the water in the boiler was noted, and all water supplied to the boiler after the test began was carefully weighed, so that the amount of water supplied to the engine is known. All water used in calorimetric tests was credited to the engine, and all drips from the main steam pipe were returned to the tanks and used again. The level of the water at the end of the test was brought back to the same point as at the beginning.

DISPLACEMENT AND CLEARANCE.

Before beginning the tests, the engine was put on each dead centre, and the volume on each side of the piston was filled with water, the valve being moved so that it covered the port in each case. The weight of the water required to fill the space and its temperature were taken at the same time, and from this data the displacement of the piston and clearance on each end was calculated.

REVOLUTIONS.

A Crosby revolution counter was attached to the shaft of each engine, and the reading of the counter was taken at regular intervals. After the counter had been adjusted for the engine, it worked satisfactorily on the Porter-Allen and Buckeye tests, and during the Southwark test, until 4.15 P. M. The number of revolutions on this test after this time are computed from the number of revolutions made by the dynamometer.

BAROMETER.

The readings of the barometer were taken from observations of the U. S. Signal Service in Philadelphia.

PRESSURE AND TEMPERATURE OF THE STEAM.

The pressure of the steam at the engine and at the boiler was taken at regular intervals, and the temperature of the steam was taken at the engine by means of a high grade thermometer set into the branch steam pipe, which led to the calorimeter used, and was very close to the engine.

QUALITY OF THE STEAM.

This was determined by using the Barrus calorimeter, a description of which is given in the Report of the Committee on Steam Boilers.

INDICATOR CARDS.

The indicated horse-power of the engines was taken. The indicator motions used were practically exact. A Crosby and a Tabor indicator were used on each cylinder, and a Crosby was used on the valve chest.

On the Porter-Allen engine test, the indicators were changed when the test was half concluded, and as the cards taken by the two indicators from the same end were as nearly identical as possible, the indicators were not changed during the other tests.

The indicator springs were tested against a Crosby steam gauge, and were found to be practically correct both in ascending and descending.

HORSE-POWER.

The areas of the cards were taken by a Crosby planimeter. The length of the cards were measured to $\frac{1}{100}$ of an inch. The mean effective pressure was determined from this data. The constant for each end of the cylinder was found by dividing the displacement in cubic inches (found by experiment) by twelve times 33,000. This result, multiplied by the mean effective pressure and by the number of revolutions, gives the horse-power developed in one end of the cylinder. The sum of these results is the total indicated horse-power of the engine.

MEAN INDICATOR CARD.

On each indicator card lines were drawn at right angles to the atmospheric line at the ends of the card, and also at ·05, ·1, ·2—·8, ·9, ·95, the length of the card. The distance from the atmospheric line to both the top and bottom of the card was measured in $\frac{1}{100}$ of an inch and tabulated, by Mr. Green, of the University of Pennsylvania.

A mean of these tabulated results is taken as the mean indicator card from which the amount of water accounted for by the indicator card is calculated. A mean of all the steam chest cards has been taken in the same way, and the mean card has been drawn. It is to be remembered that these mean cards are exactly right only at the points of the stroke already mentioned, and that this card is made of the general shape of cards actually taken.

WATER ACCOUNTED FOR BY INDICATOR CARDS.

In determining the amount of water accounted for on the indicator card, the volume of the cylinder to ·3, ·4, etc., of the stroke, including clearance, has been multiplied by the weight of one cubic foot of steam at the pressure corresponding to that point of the stroke, and from this has been subtracted the volume of the clearance multiplied by the weight of one cubic foot of steam, at the pressure to which the steam has been raised by compression.

This amount being calculated separately for each end of the cylinder, gives the weight of steam accounted for on the card for each stroke. Adding these results together and multiplying by sixty times the mean number of revolutions per minute, gives the total weight of steam accounted for per hour, and dividing by the mean horse-power, gives the water used per horse-power per hour. *It must be remembered that this is on the supposition that the steam in the cylinder was dry and saturated.*

REGULARITY OF SPEED.

These results are given at the end of this report.

The chronograph used consisted of a cylinder about four (4) inches in diameter, revolved by means of clock-work. In front of this cylinder, carried on a movable table, were two magnets with the armatures arranged in such a way that, when the circuit was closed, a point on the armature rested against the drum, and when the circuit was broken, the point was drawn back from the drum. One of these magnets was actuated by a tuning fork, making about ninety-eight double vibrations per minute, the tuning fork being kept constantly in vibration by a magnet, whose circuit is made and broken by the fork itself.

The other magnet can be actuated in any way, and the records of the two points are side by side on the drum.

During the tests, the circuit of the second magnet was made and broken at each revolution of the engine. The cylinder was covered with smoked paper, and the records made were preserved by dipping them in shellac.

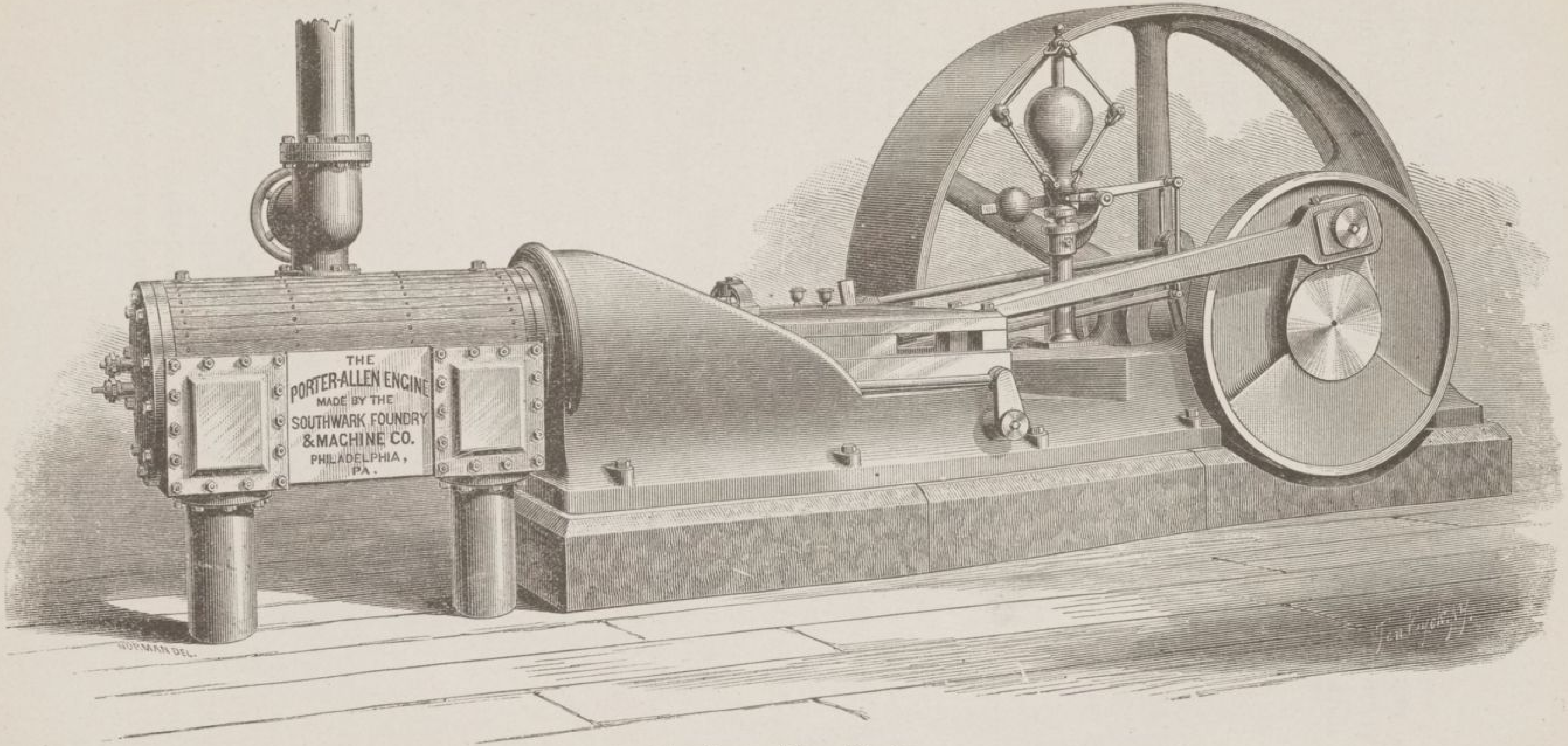
The record then shows the number of vibrations of the tuning fork occurring during successive revolutions of the engine. As it takes considerable time to prepare and adjust the apparatus, it was not possible to make continuous records.

PORTER-ALLEN ENGINE.

Test began,	1·10 P. M., October 23, 1884.
" ended,	11·10 P. M., October 23, 1884.

The engines was stopped 2·9 minutes at 6·15 P. M. to change indicators.

Diameter cylinder,	11½ inches.
Stroke,	20 "
Diameter piston rod,	1¾ "
" steam pipe,	5 "
" exhaust pipe,	5 "
Area steam ports,	6·75 square inches.
" exhaust "	10·94 " "
Diameter fly wheel (belt drum),	66 inches.
Face of " "	15 "
Weight of " "	1,000 pounds.
" " engine complete,	8,500 "
Displacement (measured)—	
Crank end of cylinder,	2018·3 cubic inches.
Head " " "	2070·14 " "
Clearance (measured)—	
Crank end,	127·87 cubic inches.
" "	6·33 % displacem't.
Head end,	136·94 cubic inches.
" "	6·61 % displacem't.
Water used in engine,	27849·07 pounds.


THE
PORTER-ALLEN ENGINE
MADE BY THE
SOUTHWARK FOUNDRY
& MACHINE CO.
PHILADELPHIA,
PA.
WORMAN DEL.

The Porter-Allen Engine.

Total time engine in operation,	9 hours 57·1 min.
Mean revolutions per minute,	227·51
Maximum " "	230·2
Minimum " "	221·8
Variation from mean speed,	+1·18 per cent.
" " " "	—2·51 " "
Mean horse-power (indicated) of engines,	69·34
Maximum " " "	76·16
Minimum " " "	63·16
Mean temperature of steam at engine,	329·33°
Maximum " " "	338·°
Minimum " " "	306·5°
Mean pressure " "	90·5 pounds.
Maximum " " "	101·6 "
Minimum " " "	59·0 "
Mean " " at boiler,	92·8 "
Maximum " " "	104·3 "
Minimum " " "	61·0 "
Mean barometer,	30·059 inches.
Mean temperature of air,	47·4° Fahr.
Mean power required to run engine with load off,	5·16 H. P.

QUALITY OF THE STEAM.

An attachment was made to the steam pipe just above the valve chest for the Barrus calorimeter, and the following results were obtained from its use:

From 4·40 to 6·40 P. M., October 23d, steam contains 13·36 % moisture
" 6·40 " 8·40 " " " " " 3·23 % "
" 8·40 " 11·10 " " " " " 6·44 % "

The average quality of the steam from this, is that it contained 7·56 per cent. of moisture.

The results of this test are shown graphically in *Fig. 1.*

The scales to which the different parts of the diagram are drawn, are shown on the left hand side of the figure. The base is divided into ten (10) minutes intervals, and the ordinates are laid off correspondingly to the observations made at the regular intervals during the test.

The line marked "Total horse-power" shows the variation in the indicated horse-power during the test.

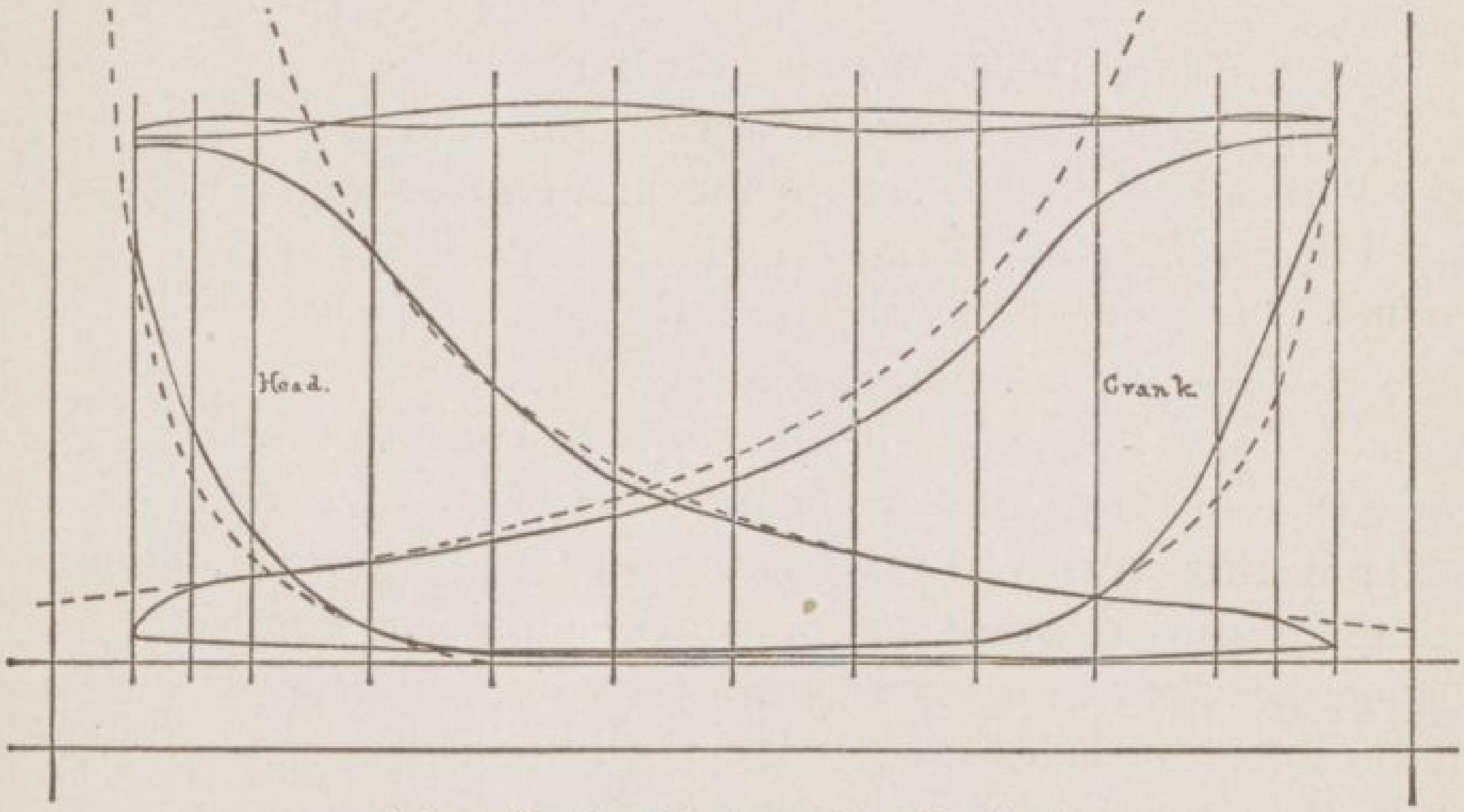
The line marked "Pressure at boiler," shows the variation in steam pressure at the boiler, while the line just below it marked "Pressure at engine," shows the corresponding pressure at the engine.

The line marked "Horse-power follower end" shows the indicated horse-power developed in the end of the cylinder away from the crank, while the line "Horse-power crank end" shows the corresponding power developed in the end of the cylinder nearest the crank.

The sun of the ordinates of the last named lines, should equal the ordinate of the line marked "Total horse-power."

The line marked "Revolutions" shows the variation of the speed of the engine, each ordinate representing the mean number of revolutions for the preceding ten (10) minutes. It will be noticed that the base line does not represent 0 revolutions, but 200. This was done that the variations should be represented on a large scale, and to make the figure as small as possible.

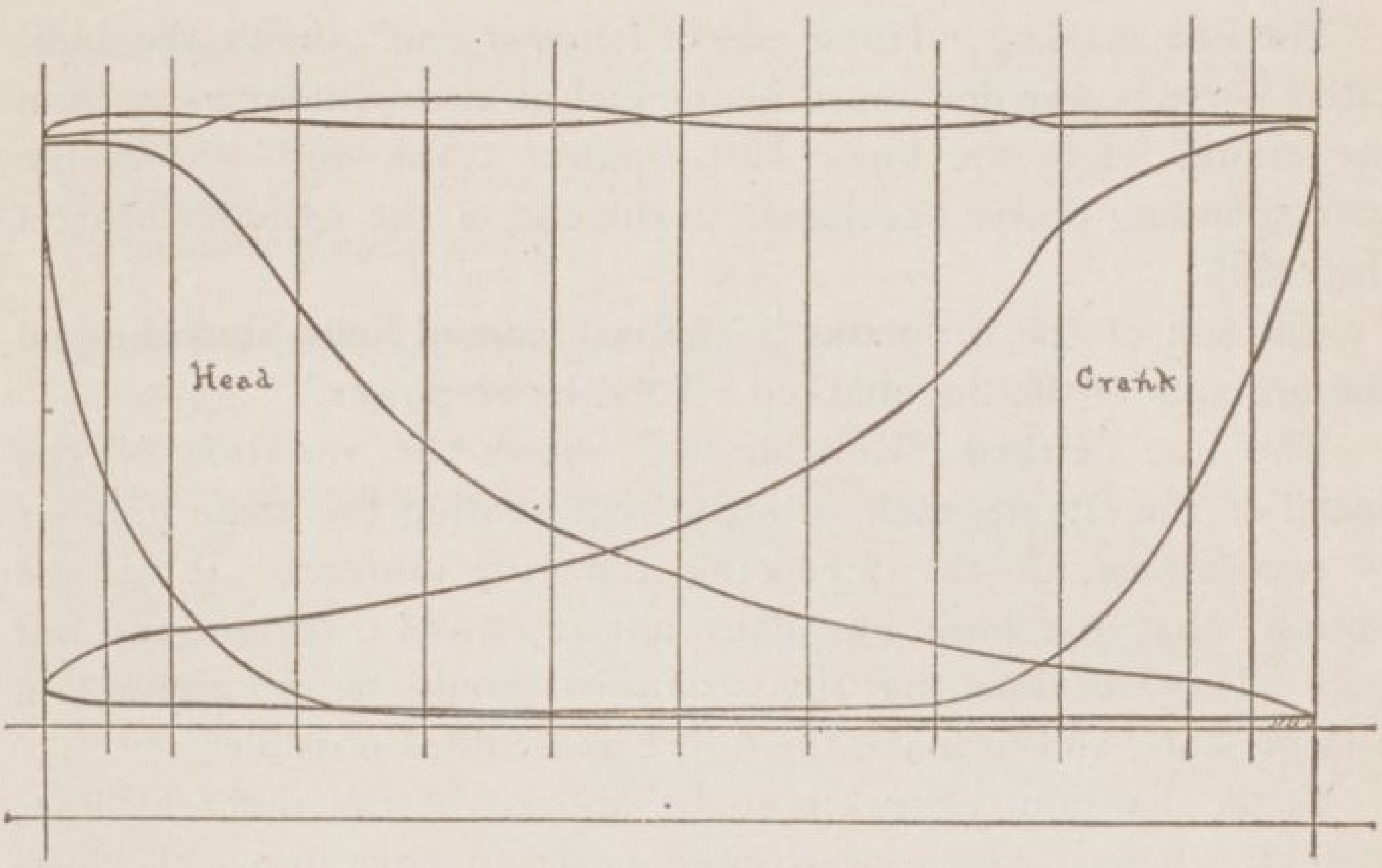
In the diagram, a break is to be noticed in the different lines at 6·15. It would have been more exact to have drawn the lines to the base line instead of breaking them.



Mean Card.—(Porter-Allen Engine.)

FIG. 2.

Fig. 2 shows the mean of all the indicator cards taken during the test, the mean being determined as before described. The clearance line is drawn at each end of the diagram, and the theoretical (hyperbola) expansion and compression lines have been drawn. The scale to which the diagrams are drawn is twenty five pounds to one inch, and the diagrams in the original are made uniformly, eight (8) inches long.



Porter-Allen, 69·38 Horse-power, 8·45 P. M., Oct. 23, 1884.

Fig. 3.

Fig. 3 is a reproduction of the cards taken at 8·45 P. M., October 23d, showing 69·38 horse-power. This card was chosen, because it comes more nearly to the mean horse-power than any other that was taken.

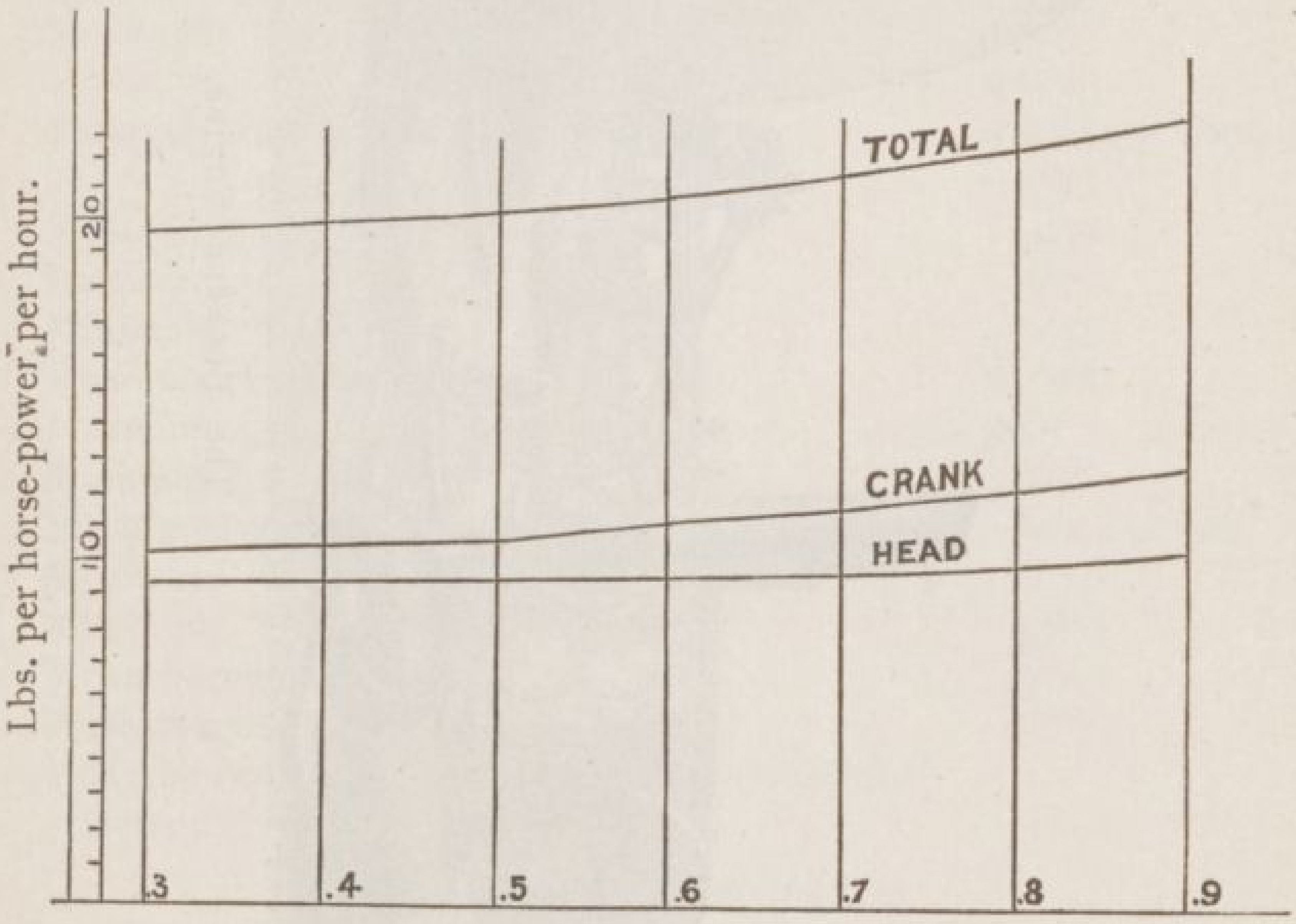
The pressures corresponding to the different parts of the stroke on the mean indicator card, are given in Table I. The first column *A* shows the points of the stroke. The columns headed *B*, show the pressure in the end of the cylinder away from the shaft, while making the stroke towards the shaft and returning, and the column headed *C*, shows the pressures in the opposite end. The column headed *D*, shows the quantity of dry saturated steam used in the cylinder per horse-power per hour from the indicator cards, using the mean number of revolutions and the mean horse-power, and allowing for the amount of steam compressed in the clearance. Re-evaporation after initial condensation is clearly shown by this:

TABLE I.

A. Part of Stroke.	*B.* Head End Cylinder.		*C.* Crank End Cylinder.		*D.* Steam Accounted for in both Ends of Cylinder.
	Advancing.	Returning.	Advancing.	Returning.	
Beginning.	86·28	70·00	87·82	81·63	Clearance, 6·3107 pds.
·05	86·22	38·00	87·72	59·86	
·1	83·88	20·79	85·30	36·42	
·2	69·62	5·47	77·10	11·12	
·3	46·60	2·00	54·72	3·18	19·8733
·4	32·80	1·64	39·70	2·58	20·0799
·5	24·04	1·40	30·42	2·38	20·3880
·6	18·11	1·22	24·40	2·40	20·8786
·7	14·03	1·05	20·18	2·42	21·5601
·8	10·92	9·6	17·06	2·63	22·2940
·9	8·92	1·21	14·84	3·18	23·3827
·95	6·82	1·60	12·74	3·36	
End.	1·88	1·85	6·82	4·32	

The amount of water used by actual weight is 44·307 pounds per horse-power per hour.

No explanation is offered save that already given as to the cause of this discrepancy between the amount of water actually

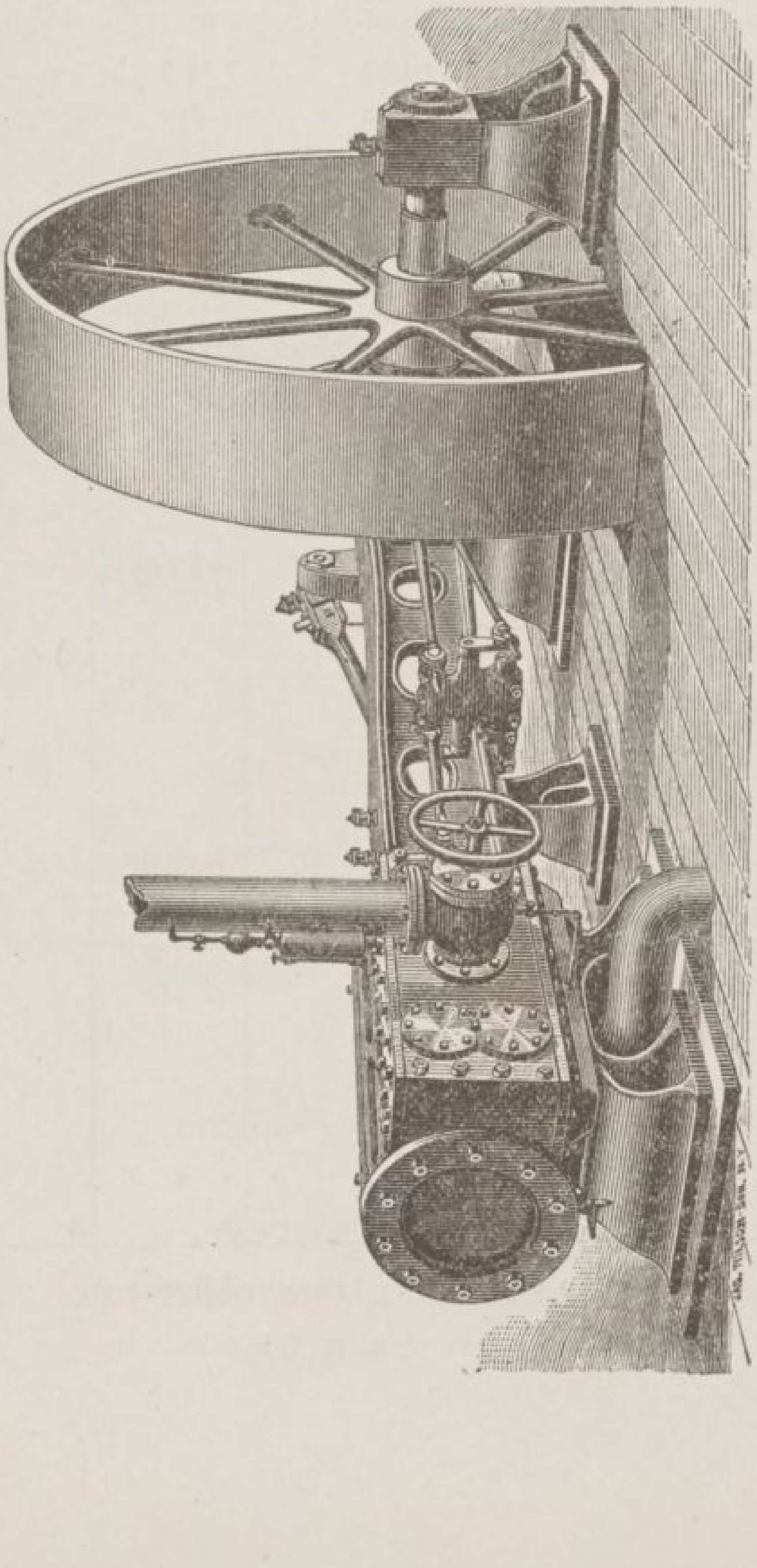


Water in Cylinder. (Porter-Allen.)

FIG. 4.

used in the cylinder and that shown on the indicator cards. The calorimeter test, which cannot be relied upon as accurate, showed an average of 7·56 per cent. of moisture in the steam. At ·9 the stroke where the amount of water shown by the cards is the greatest, the weight of water would be only $\frac{23{\cdot}3827}{{\cdot}9244} = 25{\cdot}295$ pounds, whereas 44·307 pounds actually passed through the cylinder.

Fig. 4 shows the amount of dry saturated steam which should have been present in the cylinder at the different points of each stroke, together with their sum, the upper line being simply a graphic representation of column *D*, of Table I.



The Buckeye Engine.

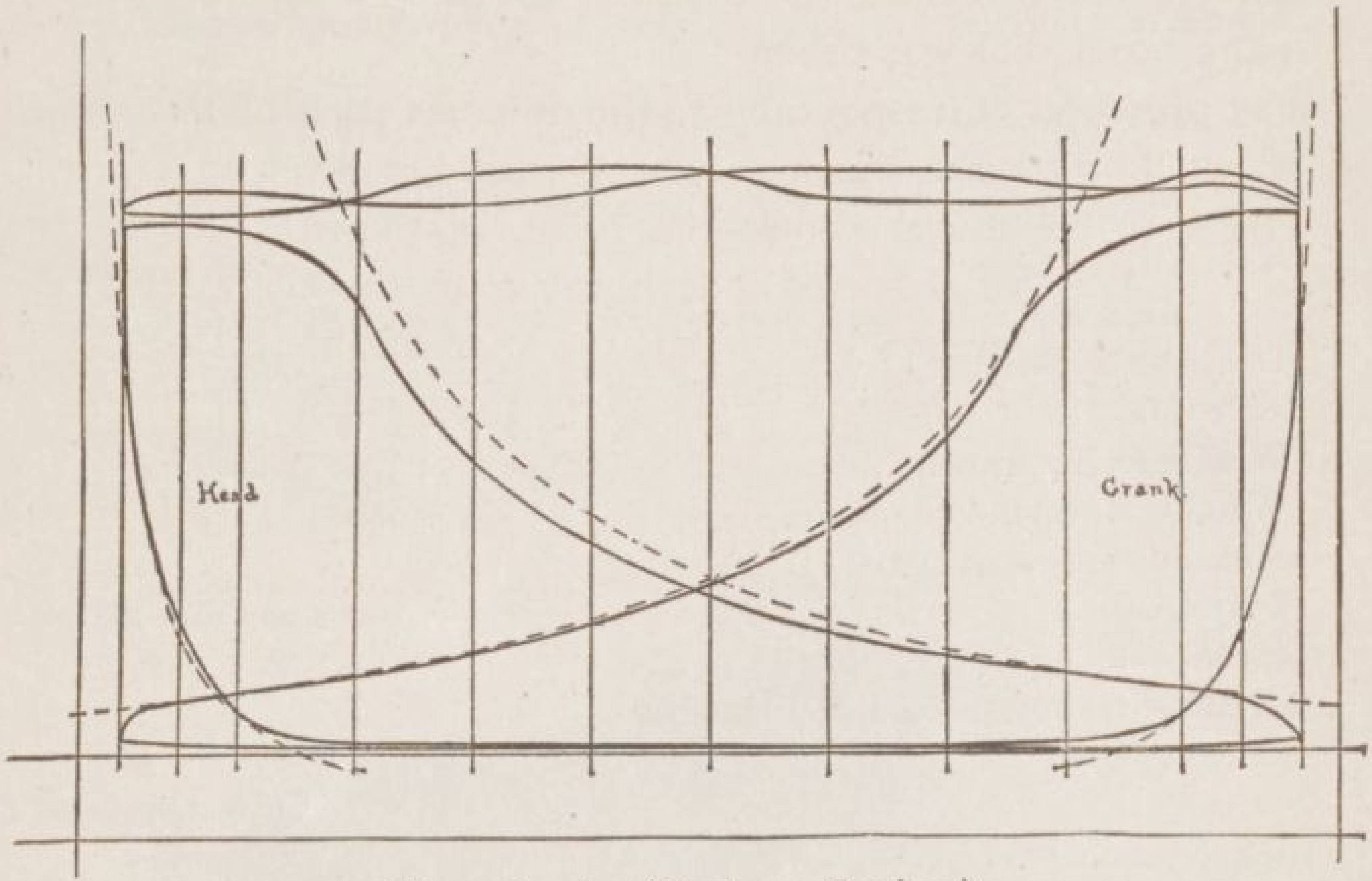
BUCKEYE ENGINE.

Test began,	6 P. M., October 31, 1884.
" ended,	4 A. M., November 1, 1884.
Diameter cylinder,	10 inches.
Stroke,	20 "
Diameter piston rod,	1½ "
" steam pipe,	3½ "
" exhaust "	4 "
Area steam ports,	⅝ x 8¾ inches.
" exhaust "	⅞ x 8¾ "
Diameter fly wheel,	84 inches.
Face of " "	19 "
Weight of fly wheel,	3200 pounds.
Weight of engine complete,	9800 "
Displacement (measured)—	
Crank end,	1464·48 cubic inches.
Head end,	1557·36 " "
Clearance (measured) to face of cut-off—	
Crank end,	47·95 " "
" "	3·27 % displacem't.
Head end,	53·57 inches.
" "	3·44 % displacem't.
Water used in engine,	16803·30 pounds.
Total time engine in operation,	10 hours.
Mean revolutions per minute,	201·11
Maximum " " "	205·6
Minimum, " " "	194·4
Variation from mean speed,	+ 2·23 per cent.
" " " "	— 3·33 " "
Mean indicated horse-power,	54·32
Maximum, " " "	56·27
Minimum, " " "	52·35
Mean temperature of steam at engine,	332·83°
Maximum, " " "	390·°
Minimum, " " "	304·5°
Mean pressure of steam at engine,	98·04 pounds.
Maximum " " "	107·30 "
Minimum " " "	89·80 "
Mean barometer,	30·012
Mean temperature of air,	46°
Mean power required to run the engine with the load off,	5·26 H. P.

QUALITY OF THE STEAM.

The quality of the steam from one observation, lasting from 7·35 to 9·00 P. M., showed the steam to contain 7·6 per cent. of moisture.

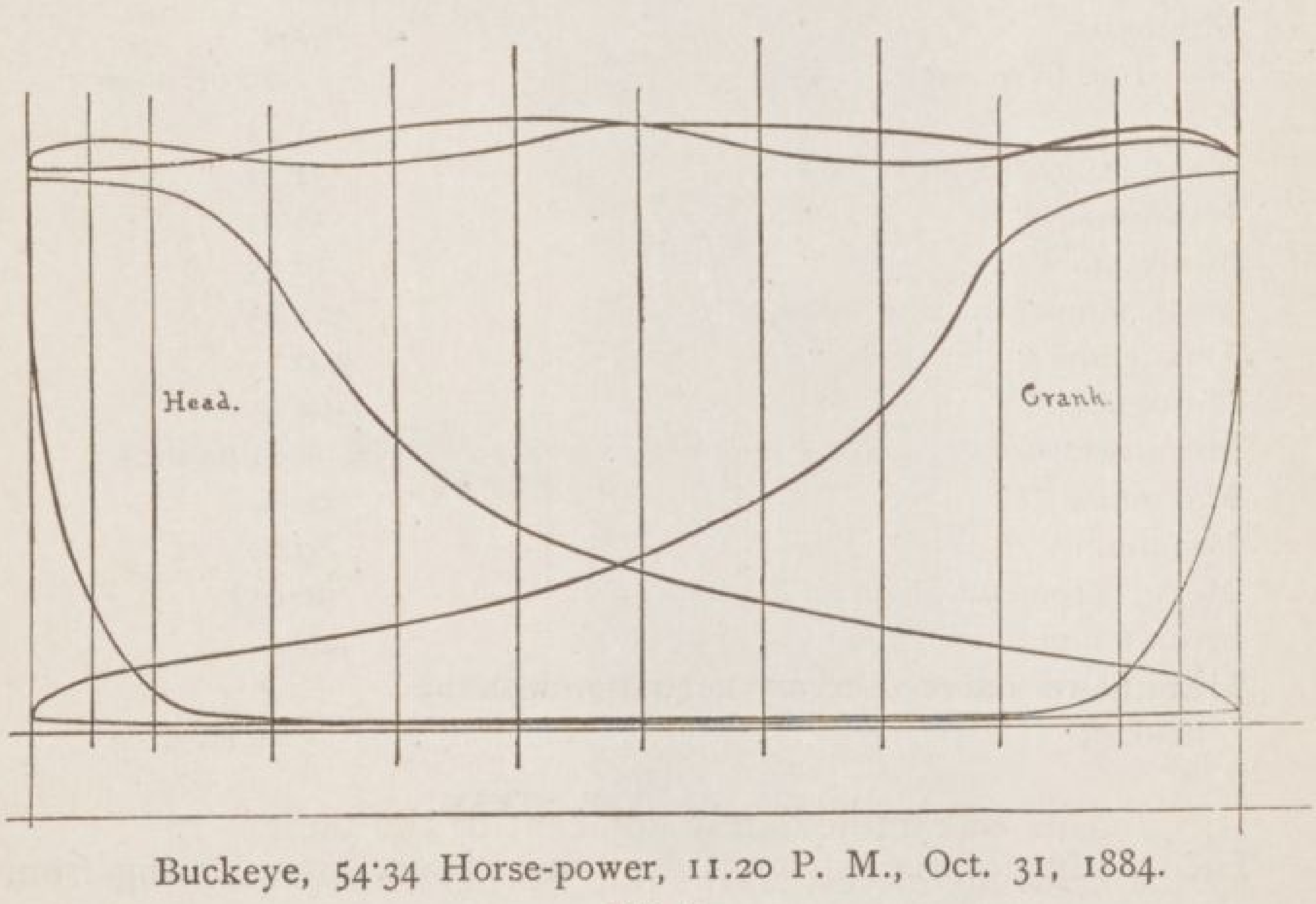
The results of this test are shown graphically in *Fig. 5*. The lines are drawn in the same way as already described for *Fig. 1*, the only difference being a slight change of scale.



Mean Card. (Buckeye Engine.)

FIG. 6.

Fig. 6 shows the mean of all the indicator cards taken during the test, the mean being determined as before described.



Buckeye, 54·34 Horse-power, 11.20 P. M., Oct. 31, 1884.

FIG. 7.

Fig. 7 is a reproduction of the cards taken at 11·20 P. M., October 31, 1884, showing 54·34 horse-power. This card was chosen because it comes more nearly to the mean horse-power than any other that was taken.

The pressures corresponding to the different parts of the stroke, which would give the mean indicator card, are given in Table II.

The first column *A* shows the points of the stroke, *B* is the pressure in the end of the cylinder away from the shaft, while the piston is making the stroke towards the shaft and returning. *C* is the pressure in the opposite end. *D* is the quantity of dry saturated steam in the cylinder per horse-power per hour from the indicator card, using the mean number of revolutions and the mean horse-power, and allowing for the amount of steam compressed in the clearance.

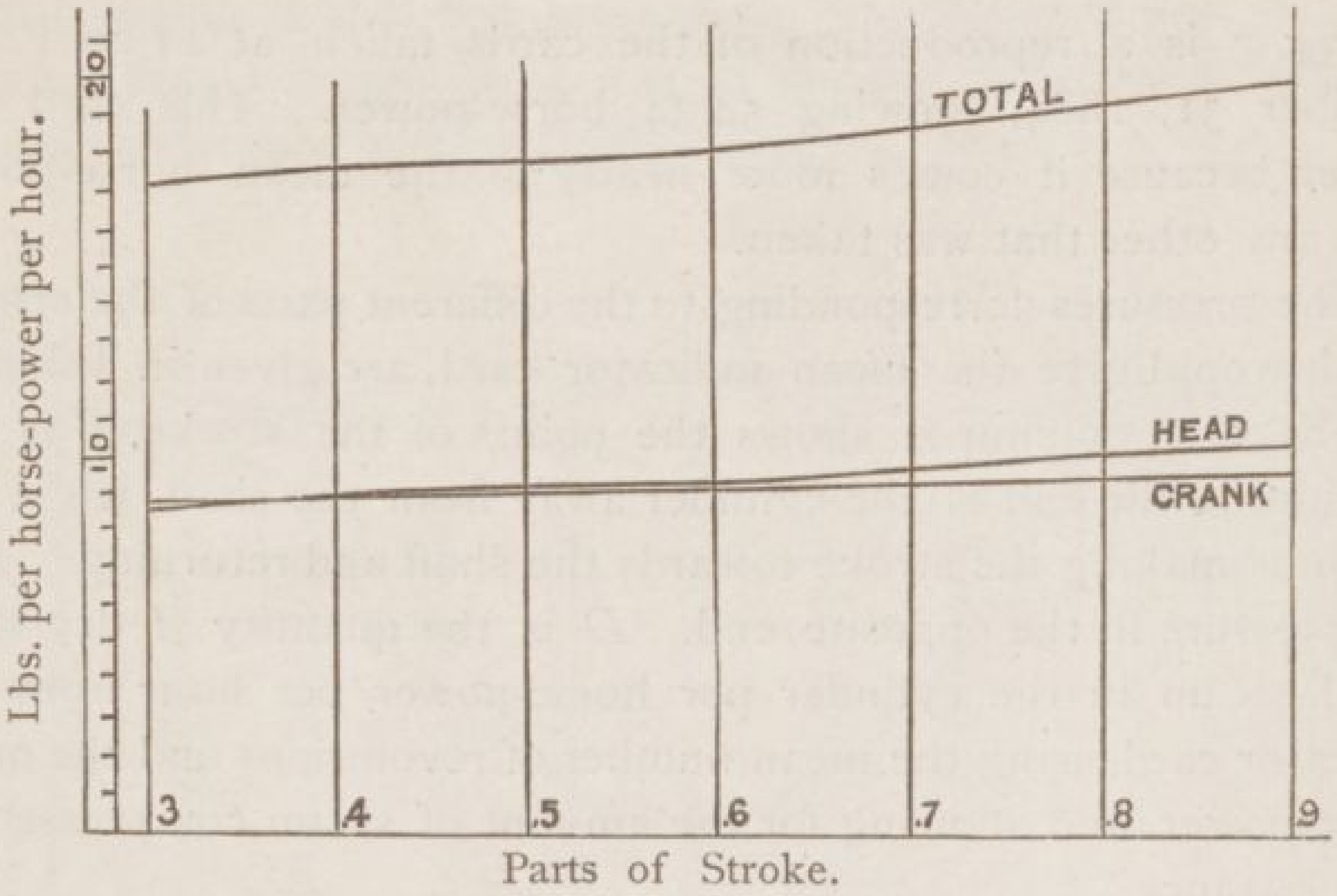
TABLE II.

A. Part of Stroke.	*B.* Head End Cylinder.		*C.* Crank End Cylinder.		*D.* Steam Accounted for in Both Ends of Cylinder.
	Advancing.	Returning.	Advancing.	Returning.	
Beginning	90·58	78·72	90·95	76·52	
·05	90·49	21·82	90·95	20·34	
·1	89·46	6·94	89·86	6·40	
·2	76·76	1·79	80·42	1·39	
·3	49·25	1·62	52·94	1·14	17·310
·4	35·04	1·50	37·40	1·08	17·743
·5	26·32	1·38	28·18	·94	18·270
·6	20·40	1·00	21·64	·90	18·713
·7	16·29	·56	16·98	·92	19·226
·8	13·12	·42	13·40	1·04	19·689
·9	10·39	·52	10·65	1·22	20·062
·95	8·28	·68	9·26	1·49	
End.	1·95	1·95	3·76	2·40	

Amount of water used by actual weight $= \dfrac{16803{\cdot}3}{10 \times 54{\cdot}32} = 30{\cdot}93$ pounds.

This engine was immediately adjacent to the boiler.

As the calorimeter test shows but 7·6 per cent. of moisture, it is evident that the steam shown on the card and that actually passing through the cylinder, vary greatly.



Steam in Cylinder. (Buckeye Engine.)

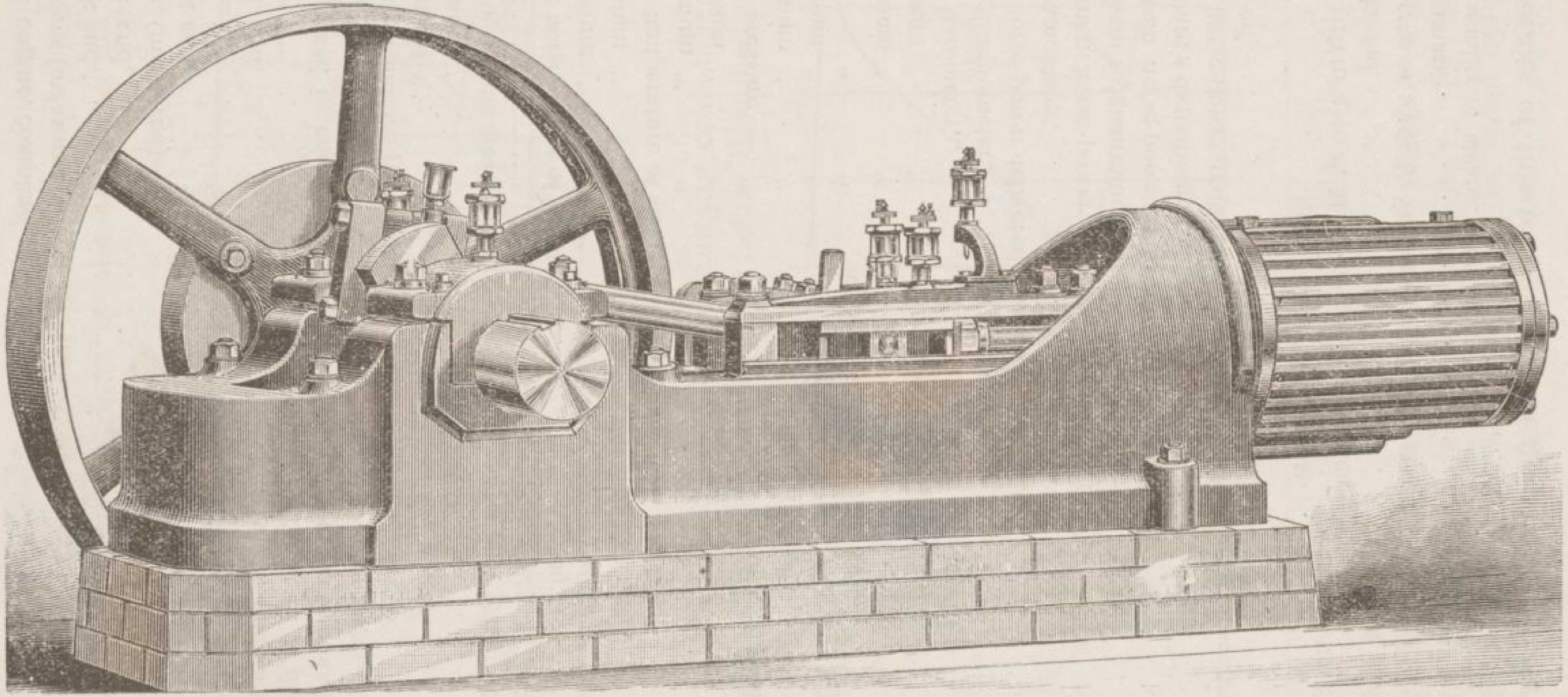
FIG. 8.

Fig. 8 shows the relative weights of dry saturated steam that should be present (theoretically) in the cylinder at different points of the stroke, together with the amount per horse-power per hour, as shown in Table II.

The power given off by this engine was transmitted directly to a Van Depoele dynamo mounted on a Brackett dynamometer cradle, and readings were taken from this dynamometer while the indicator cards were being taken. As the dynamometer was afterwards shown to be inaccurate, the results are here omitted. It is to be regretted that circumstances did not allow of a special test to determine the net horse-power delivered.

SOUTHWARK ENGINE.

Test began,	1 P.M., November 8, 1884.
" ended,	12·02 A. M., " 9, 1884.
Diameter cylinder,	9 inches.
Stroke,	10 "
Diameter piston rod,	1½ "
" steam pipe,	3 "
" exhaust "	3½ "
Area steam port,	5·7 square inches.
" exhaust "	5·7 " "
Diameter fly wheel (belt drum),	40 inches.
Face of "	8½ "
Weight of "	400 pounds.



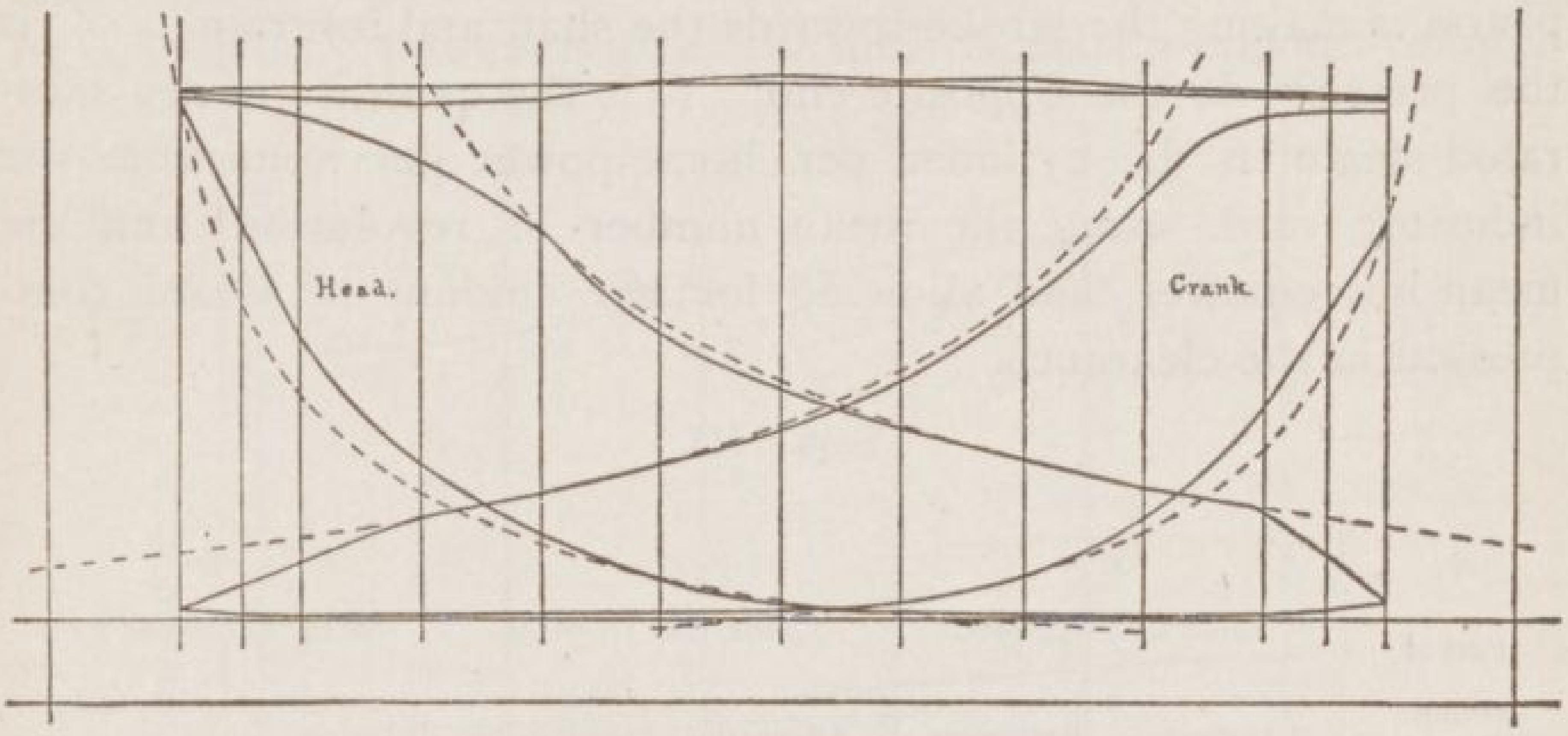
The Southwark Engine.

Weight of engine, complete,	2,600 pounds.
Displacement (measured)—	
Crank end,	606·03 cubic inches.
Head end,	633·31 " "
Clearance, (measured)—	
Crank end,	66·1 " "
" "	10·91 % displacem't.
Head end,	70·42 cubic inches.
" "	11·12 % displacem't.
Water used in engine,	14792·07 pounds.
Total time engine in operation,	11 hours, 2 minutes.
Mean revolutions per minute,	305·06
Maximum " "	309·87
Minimum " "	301·
Variation from mean speed,	+1·57 per cent.
" " " "	−1·33 " "
Mean horse-power of engine,	29·11
Maximum " " "	46·82
Minimum " " "	14·97
Mean temperature of steam at engine,	329·16°
Maximum " " "	335·°
Minimum " " "	315·°
Mean pressure " "	87·58 pounds.
Maximum " " "	96·0 "
Minimum " " "	68·5 "
Mean " " at boiler,	92·97 "
Maximum " " "	101·3 "
Minimum " " "	73·0 "
Mean barometer,	30·256
Mean thermometer,	
Mean horse-power delivered, as shown by Tatham's dynamometer,	23·44
Maximum horse-power delivered, as shown by Tatham's dynamometer,	43·15
Minimum horse-power delivered, as shown by Tatham's dynamometer,	9·13
Mean horse-power required to run engine with belt off,	4·68

QUALITY OF THE STEAM.

From 3·10 to 4·10 P. M., November 8th, steam contained,	6·7 % moisture.
From 9·50 to 10·55 P. M., November 8th, steam contained,	9·15 % "
Mean quality of steam, containing,	7·92 % "

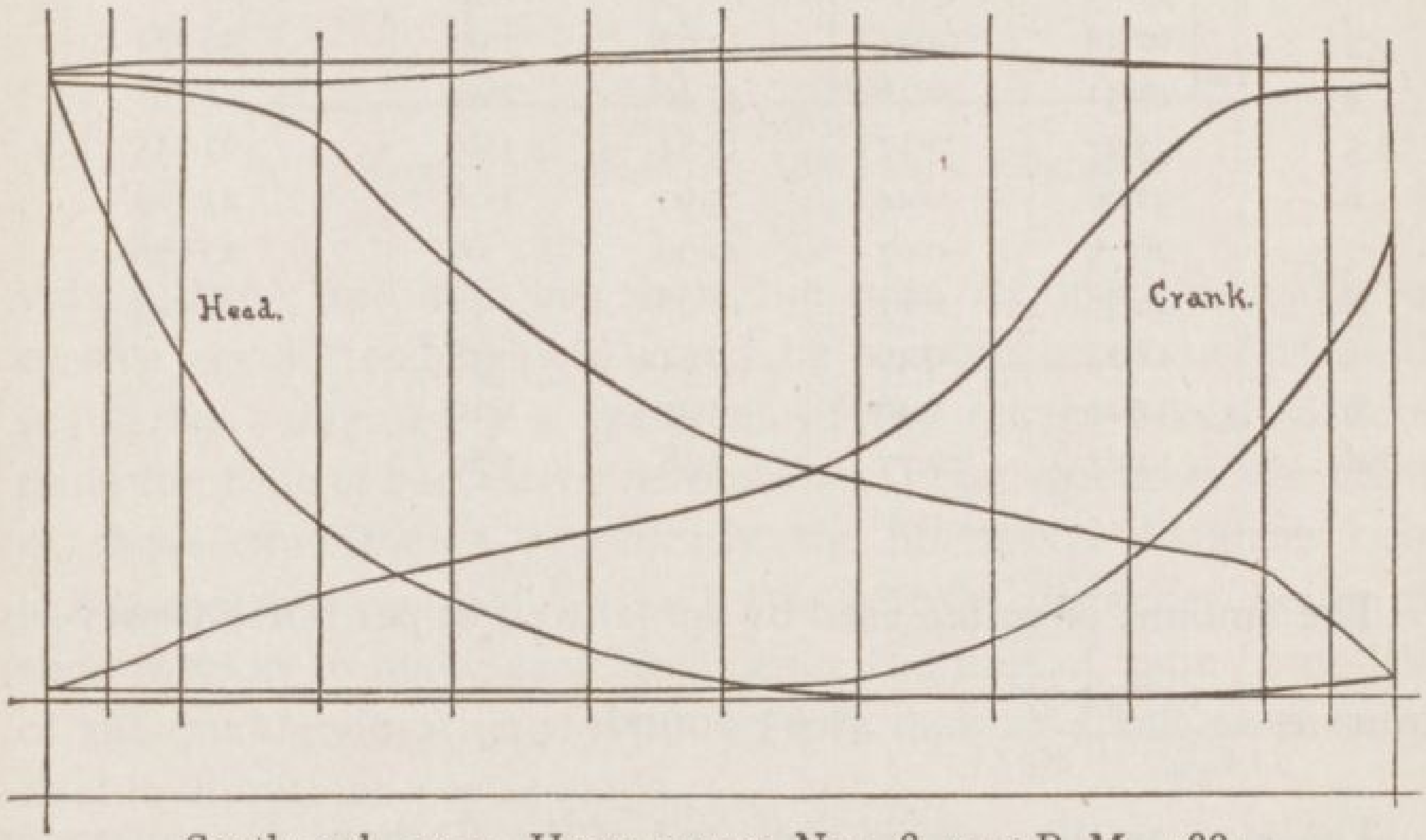
The results of this test are shown graphically in *Fig. 9.* In addition to the lines which have already been described, there is one marked "Horse-power from dynamometer," which represents the horse-power delivered by the engine to the Tatham Dynamometer.



Mean Card. (Southwark Engine.)

FIG. 10.

Fig. 10 shows the mean of all the indicator cards taken during the test, the mean being determined as before described.



Southwark, 29·21 Horse-power, Nov. 8, 7·15 P. M., 1884.

FIG. 11.

Fig. 11 is a reproduction of the cards taken at 7·15 P. M., November 8, 1884, showing 29·21 horse-power. This card was chosen, because it comes more nearly to the mean horse-power than any other that was taken during the test.

The pressures corresponding to the different parts of the stroke, which would give the mean indicator card, are given in Table III.

The first column *A* shows the points of the stroke. *B* is the pressure in the end of the cylinder away from the shaft, while the piston is making the stroke towards the shaft and returning. *C* is the pressure in the opposite end. *D* is the quantity of dry saturated steam in the cylinder per horse-power per hour from the indicator card, using the mean number of revolutions and the mean horse-power, and allowing for the amount of steam compressed in the clearance.

TABLE III.

A. Part of Stroke.	*B.* Head End Cylinder.		*C.* Crank End Cylinder.		*D.* Steam Accounted for in both Ends of Cylinder.
	Advancing.	Returning.	Advancing.	Returning.	
Beginning.	86·80	87·56	84·99	67·14	
·05	86·08	66·21	84·99	50·55	
·1	83·90	47·38	84·32	35·02	
·2	76·69	25·56	71·05	16·92	
·3	62·58	14·25	52·62	7·00	20·781
·4	47·51	6·36	39·40	2·44	21·201
·5	37·97	2·17	31·84	1·36	22·155
·6	32·06	0·44	25·60	1·08	23·107
·7	26·75	0·07	20·90	·69	23·676
·8	22·38	0·11	17·08	·42	24·045
·9	18·24	0·49	9·74	·58	
·95	11·20	1·46	5·27	1·16	
End.	3·47	2·77	1·98	1·80	

The amount of water used by actual weight per horse-power per

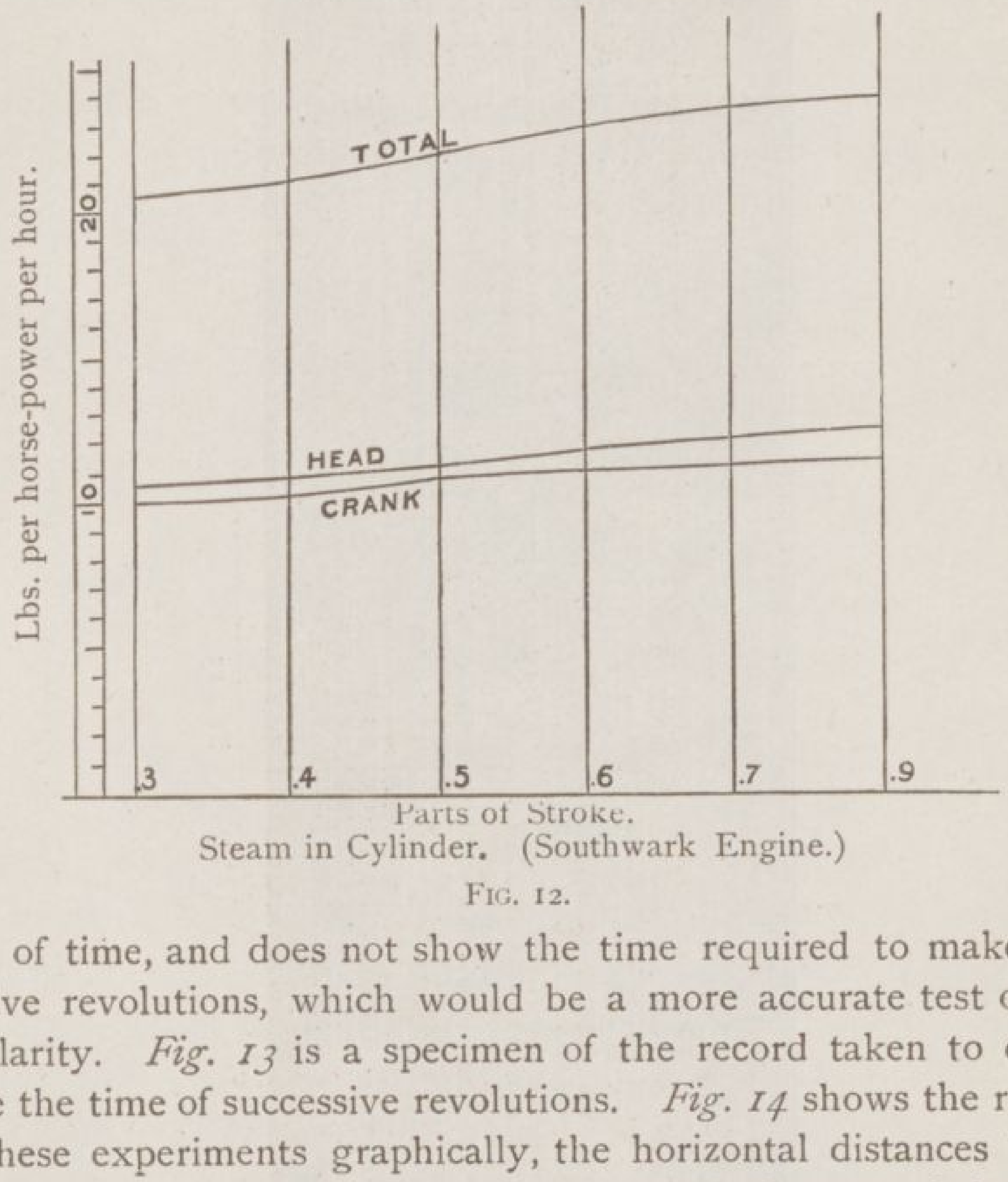
$$\text{hour} = \frac{14792{\cdot}07}{11\tfrac{1}{30} \times 29{\cdot}11} = 46{\cdot}05 \text{ pounds.}$$

The load on this engine consisted of the Tatham dynamometer and a friction brake, and the variation in this latter caused the great variation in the horse-power lines on *Fig. 9*.

Fig. 12 shows the relative weights of dry saturated steam that should be present (theoretically) in the cylinder at different points of the stroke, together with the amount for horse-power per hour, as shown in Table III.

REGULARITY OF SPEED.

A good idea of the regularity of speed can be obtained from *Figs. 1, 5* and *6*, which show the average number of revolutions made by the engine for each ten or fifteen minutes, as the case may be. This only, however, gives the mean speed for successive intervals of time, and does not show the time required to make successive revolutions, which would be a more accurate test of the regularity. *Fig. 13* is a specimen of the record taken to determine the time of successive revolutions. *Fig. 14* shows the results of these experiments graphically, the horizontal distances being the successive revolutions, and the vertical distances being the time it takes to make each revolution, the unit of time being that of the double vibration of a tuning fork making about ninety-eight double vibrations per seconds.



Steam in Cylinder. (Southwark Engine.)

FIG. 12.

During both the Porter-Allen and the Southwark tests a number of diagrams were taken, but only the results of those showing the last and greatest variation in speed are shown in *Fig. 14*. The following table, No. IV., gives the time of making successive revolutions in beats of the tuning fork, and they can be reduced to revolutions per minute by dividing with 5,880 = (98 x 60) :

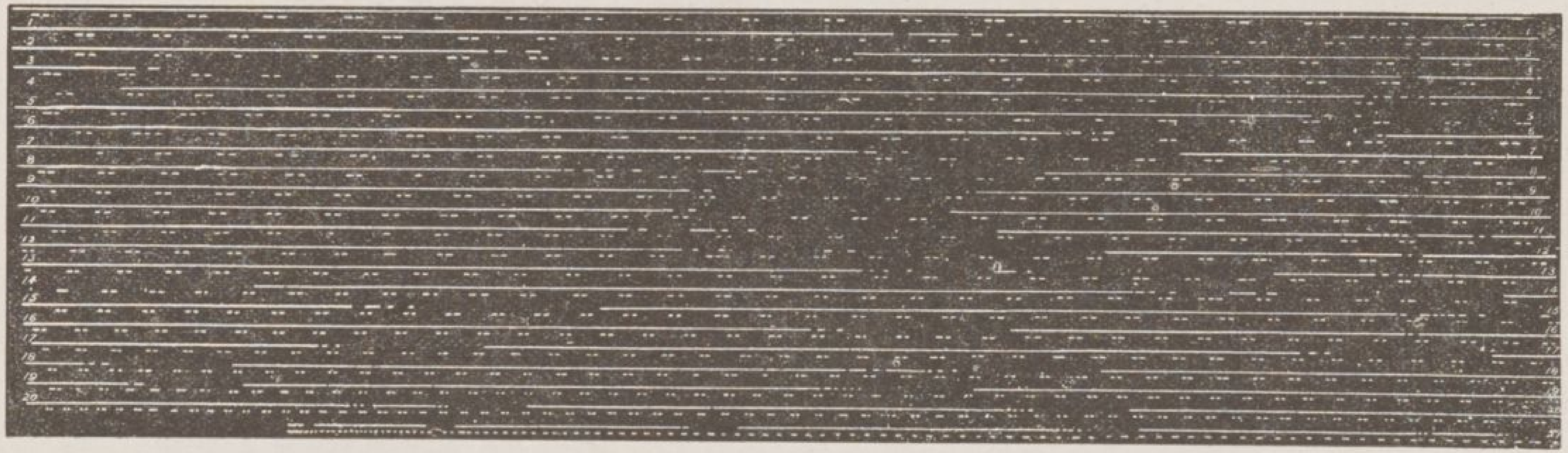
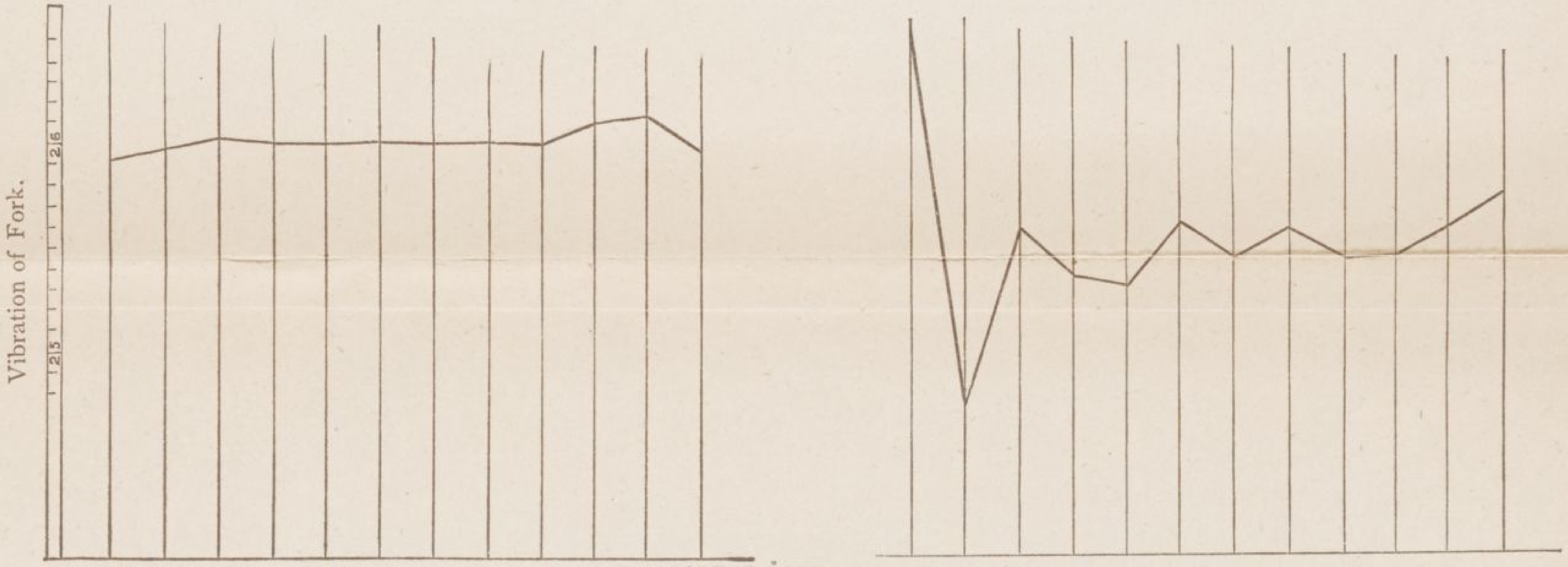
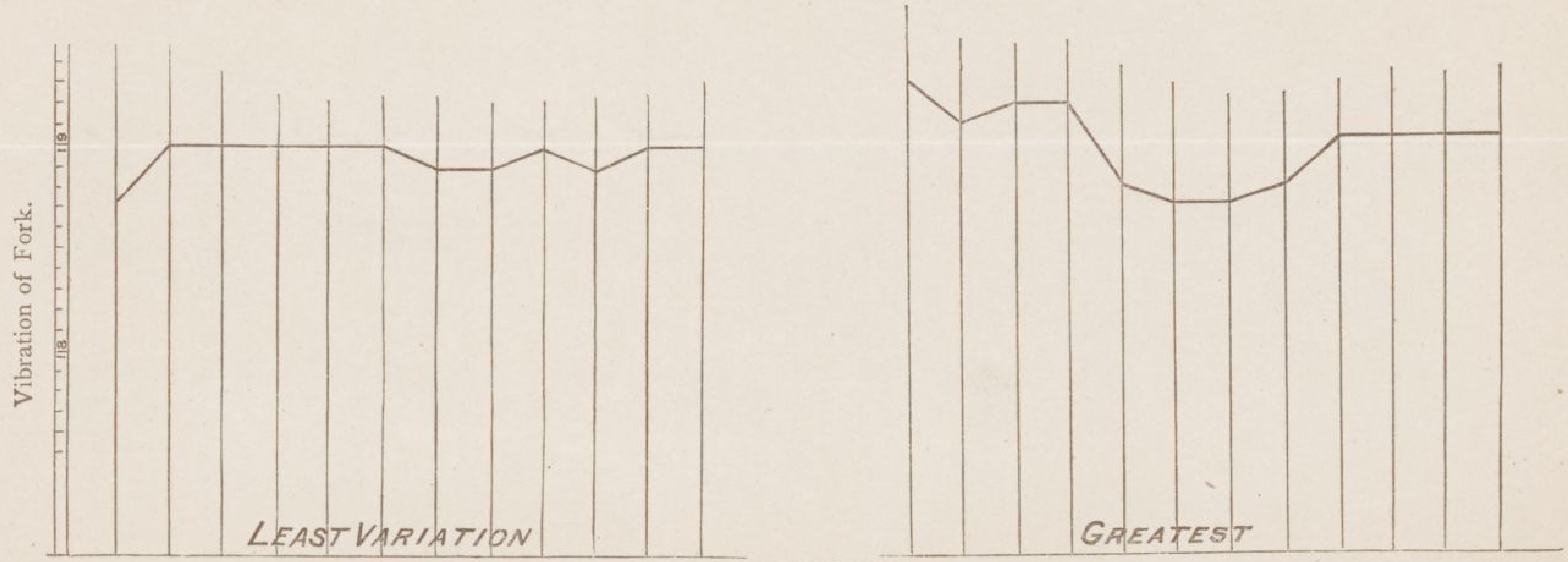


Fig. 13

International Electrical Exhibition. (*Report of Examiners, Section XI. Fig. 14.*)



PORTER-ALLEN ENGINE.



SOUTHWARK ENGINE.

TABLE IV.

PORTER-ALLEN.		SOUTHWARK.	
Minimum Variation.	Maximum Variation.	Minimum Variation.	Maximum Variation.
25·92	26·51	18·75	19·3
25·96	24·72	19·00	19·1
26·13	25·56	19·0	19·2
26·00	25·33	19·0	19·2
26·00	25·30	19·0	18·8
26·07	25·60	19·0	18·7
26·00	25·43	18·9	18·7
26·01	25·55	18·9	18·8
26·00	25·41	19·0	19·0
26·10	25·43	18·9	19·0
26·13	25·57	19·0	19·0
25·95	25·71	19·0	19·0

The nearly continuous line of *Fig. 13* is from the armature, making record of the revolutions of the engine, and as the circuit was broken at only one point in the revolutions, the tracing point would make a continuous line, except during one small interval. The dots right under this line are made by the other armature. connected with the tuning fork. *Fig. 15* will show the manner of connecting and using the apparatus. All the apparatus shown in the figure, excepting the piece marked *T* and the cells *V*, *W* and *X*, is on one base and works as follows: The tuning fork *Z* is kept in vibration by means of the single Leclanché cell *X*, which is connected to the binding posts *A* and *B*. *A* is connected directly to the tuning fork *E*, as the whole apparatus rests on an iron base, and *E* and *A* are not insulated. The current passes from *X* to *B*, then around the magnet *G*, then to the insulated contact piece *F*, through the contact piece to the fork *Z*, from *E* to *A*, and back to the cell *X*.

The vibration of the fork makes and breaks contact at *F*, magnetizing and demagnetizing *G* and keeping the fork vibrating with about a constant amplitude of vibration.

The drum *P* is the drum on which the records are made. *N* and *O* are two small magnets with their armature balanced horizontally in such a way that while the circuit is closed through them, the points *a*, *a*, rest against the drum, and when the circuit is open a light spring draws the points clear of the drum. The magnet *O* is the one represented as recording the vibrations of the fork. The binding posts *I* and *K* are connected to the coil of the magnet.

The current from the cell *W* passes from *W* to the uninsulated post *C*. From *C* through the frame to the fork *Z*, through the contact piece to the insulated post *H*, which is connected to the binding post *D*, also insulated. *D* is connected to *I* and the current, after passing through the coil of the magnet, passes through *K* back to the cell *W*. As the current is broken at *H* the point *a* is raised from the drum *P*, and as soon as the circuit is closed, the point *a* again rests on the drum *P*.

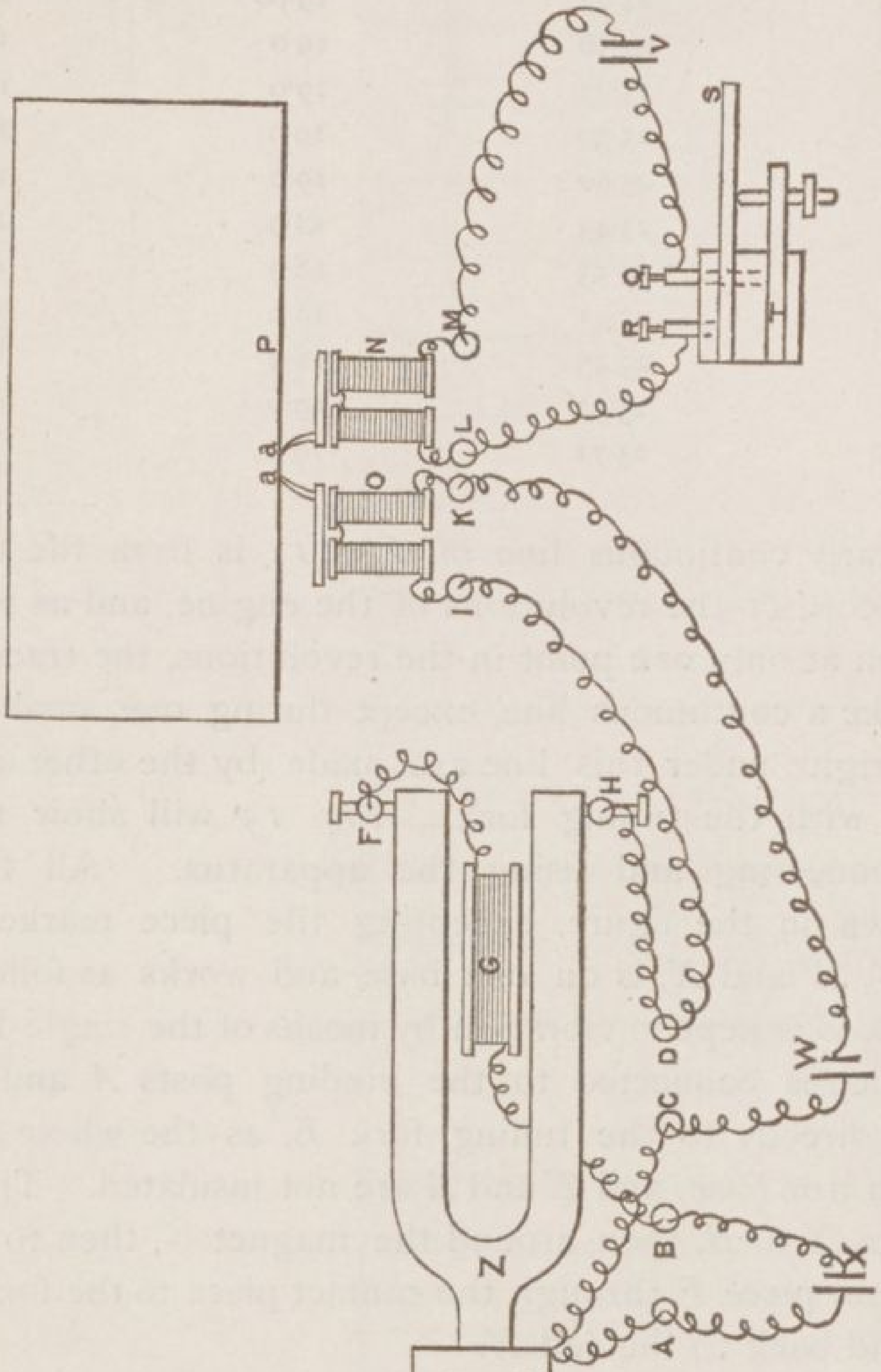


Fig. 15.

The record of the other magnet is made as follows: *T* is the break circuit piece. It consists of two brass pieces, *S* and *T*, insulated from each other and connected to the binding posts *R* and *Q*. *U* is a contact screw. *S* is put in such a position that a projection on the engine strikes *S* once a revolution, breaking contact with *U*. Connections are made, as shown, to the magnet *N*, and when the circuit is closed, the current flows through *M*, *N*, *L*, *R*, *S*, *U*, *T*, *Q*, and back to the cell *V*, in the order named.

In addition to the records made by this apparatus the following experiment was made on the Porter-Allen engine. The projecting end of the shaft was covered with blackened paper, and while the engine was in operation a point attached to one arm of a tuning fork was brought against the paper for a single revolution. This was repeated a number of times.

A straight line was drawn on the paper cutting the marks made by the fork, and the distance between successive vibrations has been plotted. The results are shown in *Fig. 16*. The ordinates are the actual distances between vibrations in inches. The abcissæ are equal intervals of time during one revolution. The points marked *D* represent the dead points. An examination will show that the changes in speed do not take place at any particular place in the stroke, and none of the diagrams taken show any more marked variation than those in the figure.

The thanks of this Committee are due to the following parties:

The Crosby Steam Gauge and Valve Company, Boston, Mass., for planimeters, gauges, indicators and test pumps, all of which proved of excellent workmanship.

The American Steam Gauge Company, Boston, Mass., for Tabor indicators, which worked well. A Mosscrop speed indicator, loaned by the same firm, was not used.

Riehlé Brothers, Philadelphia, Pa., for use of scales.

M. B. Edson, for a very accurate recording and alarm gauge.

The students of the Department of Dynamical Engineering, University of Pennsylvania, already mentioned in "Report on Boilers," for services as observers and computers.

As none of the exhibitors made application for a competitive test as prescribed under the code, all tests are quantitative. The uncertainty of the Committee as to the correctness of the calorimetric observations, and the fact that the engines were placed at

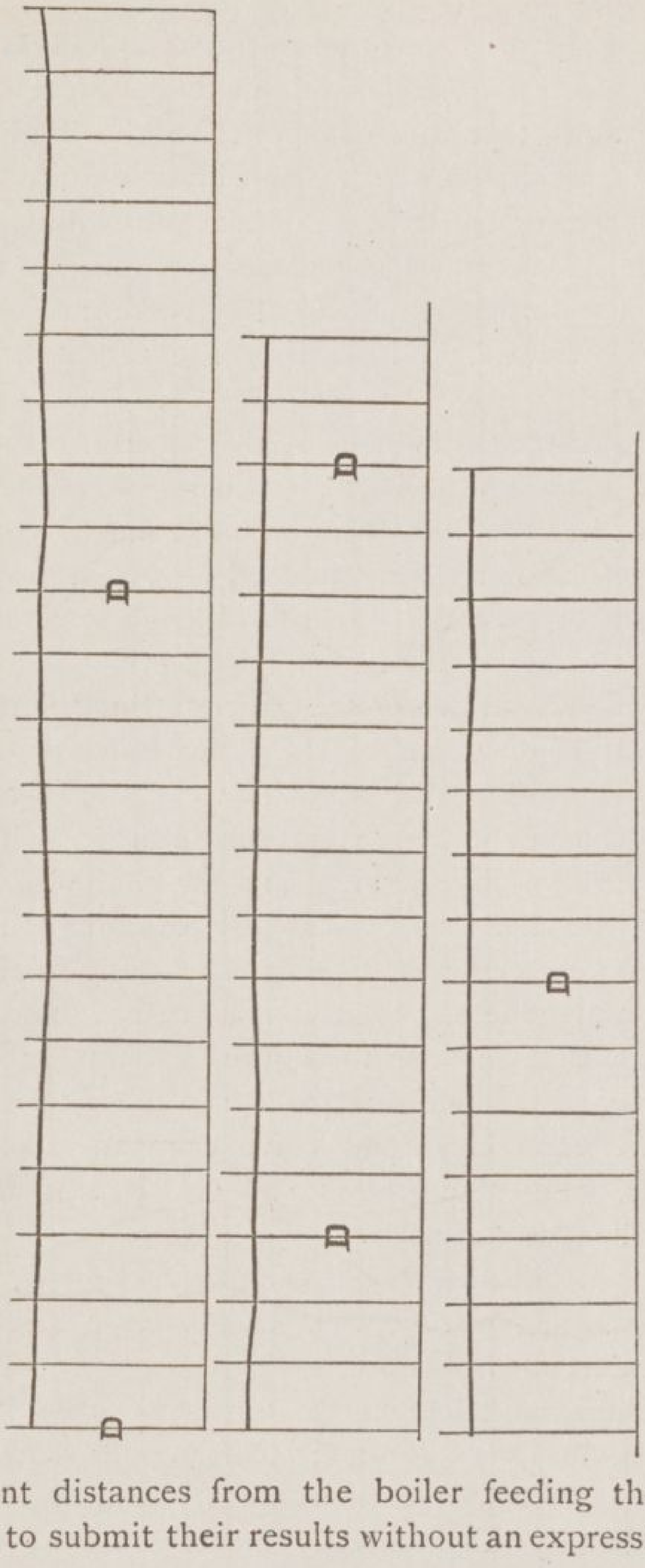


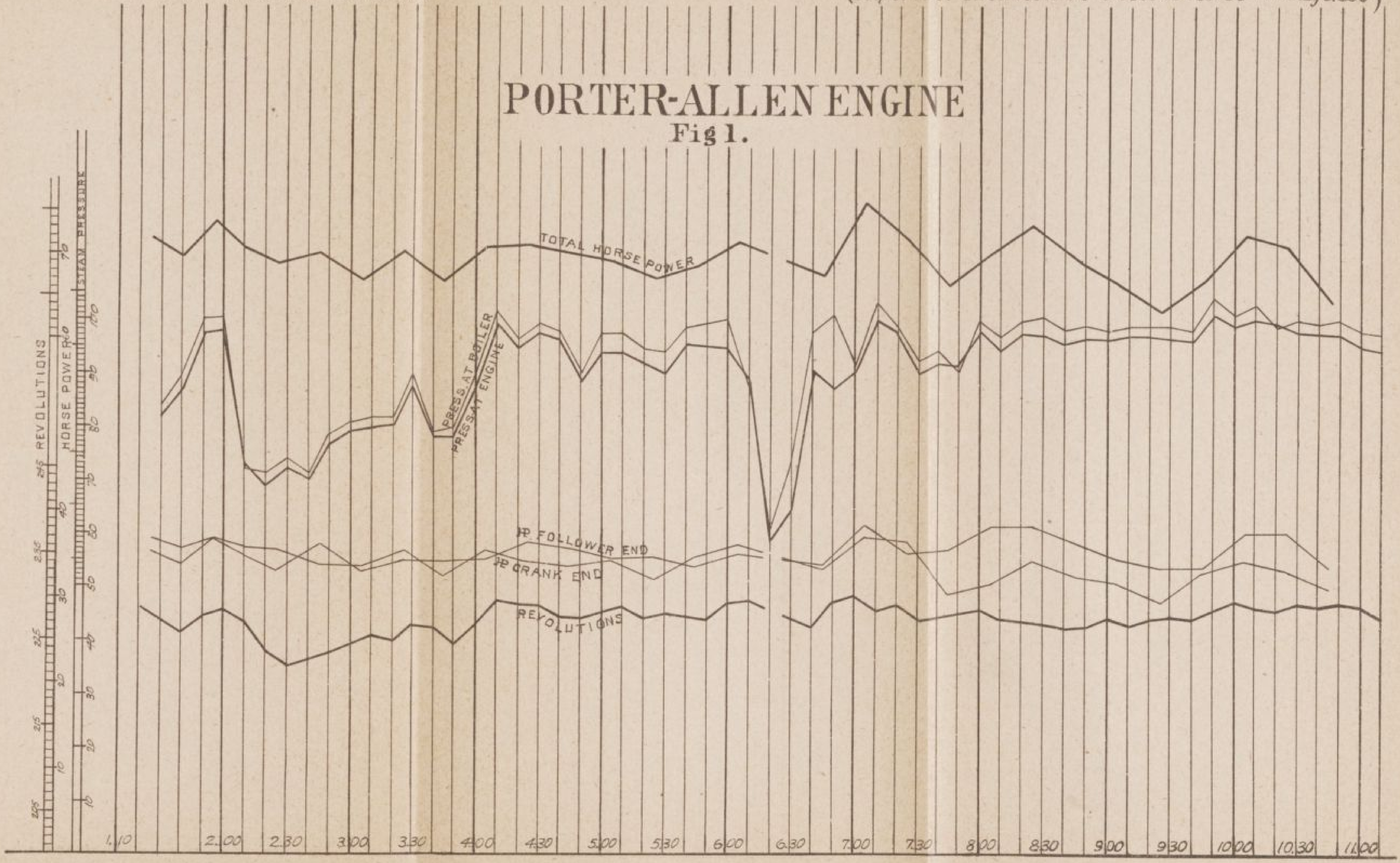
FIG. 16.

very different distances from the boiler feeding them, cause the Committee to submit their results without an expression of opinion.

W. D. MARKS, *Chairman.*
CHAS. E. RONALDSON.
W. B. LEVAN.
Committee Present.
H. W. SPANGLER, *Secretary.*

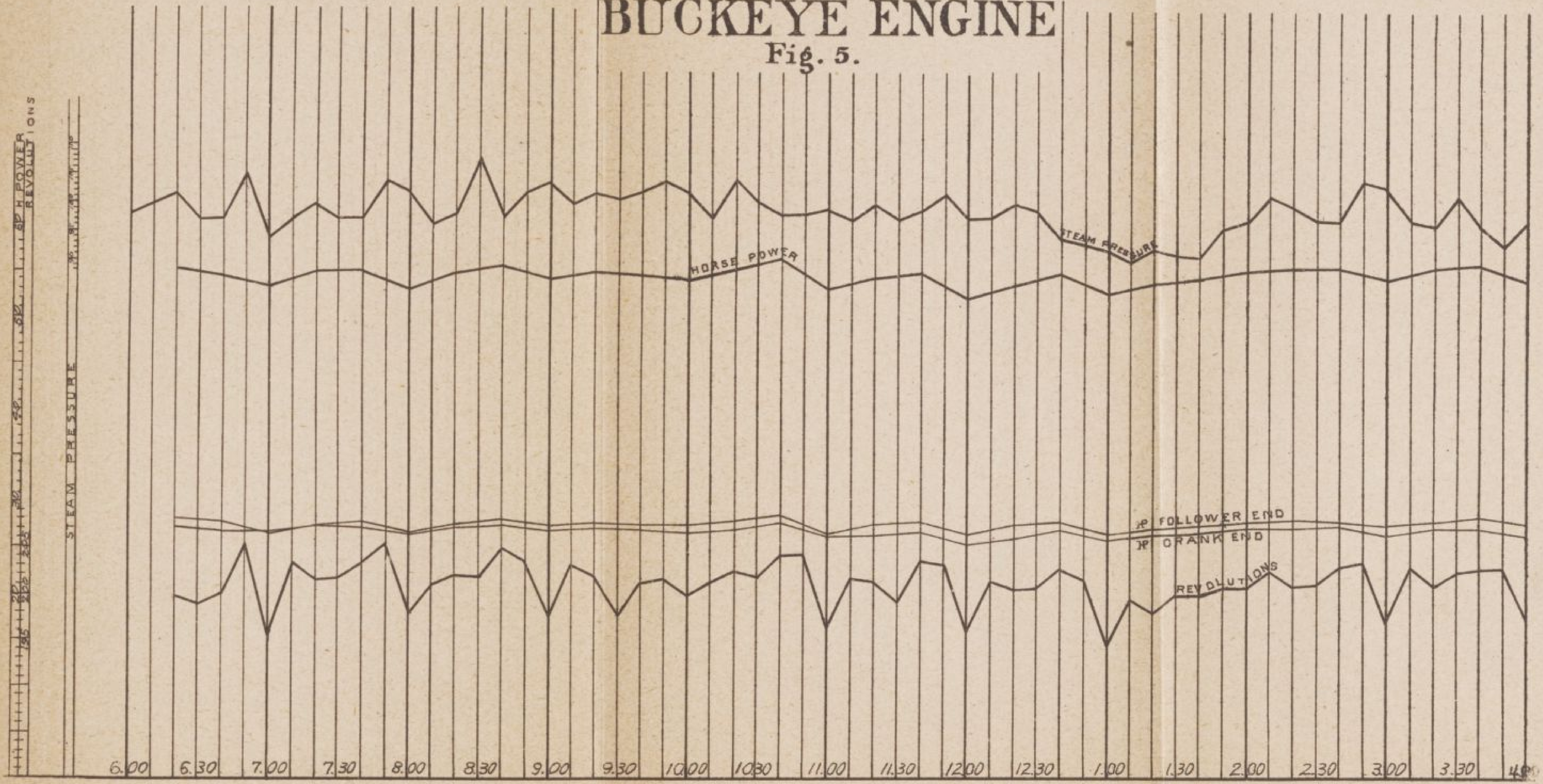
PORTER-ALLEN ENGINE

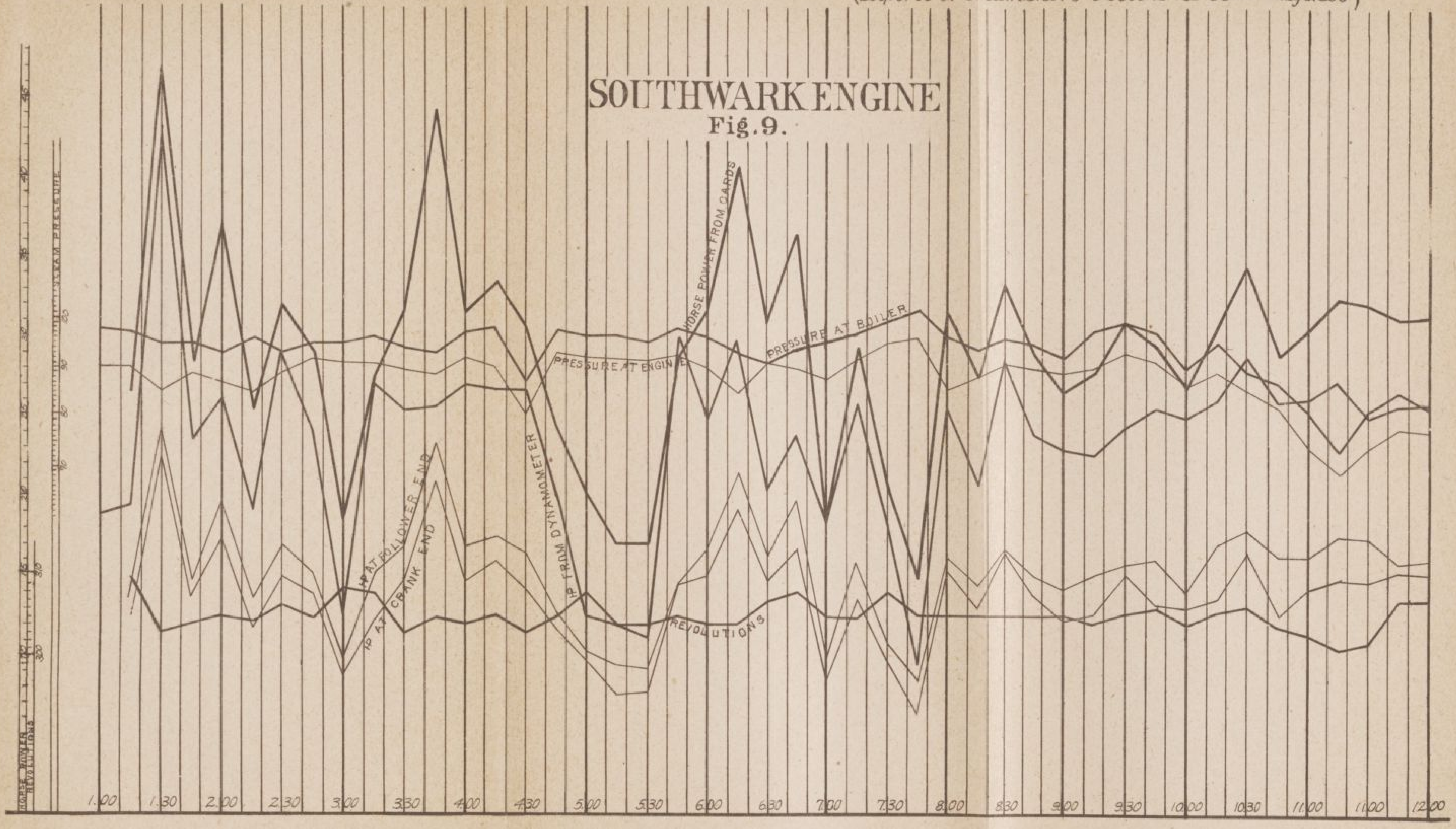
Fig 1.



BUCKEYE ENGINE

Fig. 5.





SOUTHWARK ENGINE
Fig. 9.

TK6
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1884–INTERNATIONAL ELECTRICAL EXHIBITION–1884

REPORT OF EXAMINERS
OF
SECTION XVIII.

43/8334

UNDERGROUND CONDUITS.

"Merrihew Print" (J. Spencer Smith), 501 Chestnut St.

With the compliments of

Persifor Frazer

Philadelphia.

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

OF THE

FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS

REPORT OF EXAMINERS

—OF—

SECTION XVIII.

(SECTION II., CLASS IV. OF THE CATALOGUE.)

UNDERGROUND CONDUITS.

43/8334

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t.c. — June 1, 1904 - G.W.C.
G.G.B. no. 23/06

INTERNATIONAL ELECTRICAL EXHIBITION, 1884.

FRANKLIN INSTITUTE, Philadelphia, Pa.

REPORT OF EXAMINERS.

SECTION XVIII.—UNDERGROUND CONDUITS.

To the Board of Managers, Franklin Institute:

GENTLEMEN:—I have the honor to transmit herewith the report of the Examiners of Section XVIII, on Underground Conduits.

Respectfully,
M. B. SNYDER,
Chairman Board of Examiners.

PHILADELPHIA, *December*, 1884.

Chairman Board of Examiners, International Electrical Exhibition:

SIR:—The following report of the Examiners in Section XVIII (on Underground Conduits), is respectfully submitted.

F. D. DE WOLSKI (*Ch'n*),
Examiners of Section XVIII.

PREFACE.

In submitting a report on the various underground conduits exhibited at the International Electric Exhibition the undersigned Examiners desire to mention that their task would have been a much easier one had each exhibitor furnished them at the outset with a brief practical description of his system. In fact few of them did themselves justice in this respect.

The undersigned carefully examined the models, in the presence, as far as possible, of the exhibitors themselves, and some of the members inspected the systems in practical operation in the city of Philadelphia. They regret they were unable to carry out any system of tests owing to want of time and absence of facilities.

A programme was drawn up by Dr. Frazer, and approved by the Section, to assist the examiners in framing their individual reports on each system, and will be found attached to this report.

Although the examiners abstained as far as possible from entering into the comparative merits of the systems, the examiners considered it advisable to note the obvious merits and demerits of each system, so far as they had means of judging. The points upon which they have commented are such as a sufficient experience of analagous contrivances enabled them to judge of from the bare statements and descriptions. In no case was it possible to state from actual observation of the working of any of these systems, that they did or did not fulfil what was claimed for them.

Your examiners are of the opinion that during the experimental stage of underground conduit construction for electric currents, it is desirable, in the interest of the community in which such conduits are laid, that the latter be capable of use for as many different purposes, and by as many different companies as possible: and also be capable of inspection in every part, and removal or replacement with the greatest possible rapidity, and the least possible obstruction to the public highways.

The rapid advance of electrical science in the past renders it nearly certain that the next few years will witness great changes in the methods for the production and distribution of this form of energy; and with an unelastic system in which a corporation may have expended large sums of money, the practical advantages of the introduction of electricity may be entirely dissipated for a long time. For the same reason it seems to the undersigned unadvisable at the present time for a corporation to adopt any style of plant which is adapted only to one system of distribution, however excellent the system may seem to be.

They feel impelled to add one final word in view of the doubt that has been expressed as to the feasibility of constructing underground conduits for all purposes of electrical distribution. Certainly, at least, within the limits of large cities, whether or not it be found in the future to be desirable to enclose telephone and telegraph, with light and power circuits; or any two of the foregoing in the same conduit, they express no opinion, but that the electric current for any and all of these purposes can be successfully transmitted underground, there is not the least reason to question.

They believe that a careful series of tests, made by competent experts, on the systems already laid, would be of great value to science, and to all those who are interested in the use of the electric current.

ALPHABETICAL LIST OF THE EXHIBITS VISITED BY THE COMMITTEE.

(SECTION XVIII.)

The exhibits mentioned here do not include all of those mentioned in Section II., Class IV. of the catalogue. Some of these latter do not properly belong to the "underground" class; some of them were not found by the committee, and some had no one to explain them, and no printed or written descriptions which could be procured.

For one or more of these reasons the undersigned examiners have been obliged to omit mention of some exhibits which are classed in the catalogue under the head of Section II., Class IV.

(*Form of sheet with blanks prepared for the use of members of the Section.*)

INTERNATIONAL ELECTRICAL EXHIBITION
OF THE
FRANKLIN INSTITUTE,
September and October, 1884, at Philadelphia.

Programme for Examination, by Section XVIII. of the Board of Examiners,

IN SECTION II., CLASS IV.
OF THE CATALOGUE.

(UNDERGROUND CONDUITS FOR ELECTRIC CONDUCTORS.)

DIVISION OF THE WHOLE SUBJECT.

A.—Advantage or disadvantage to those using currents.
  - *a.* Electrodes permanently sealed.
  - *b.* Electrodes capable of being inspected at every part.

B.—Advantage or disadvantage to the communities at large.
  1. In city streets.
  2. Adaptability for different companies to use in common.
  3. Relative supply.

C.—Systems undeveloped or partially developed.

Members of the Section are requested to fill up as many as possible of the blanks for as many as possible of the exhibits, and to forward their notes to the Chairman of the Section, Captain de Wolski, at the building.

HOW DO THE SEVERAL EXHIBITS STAND WITH RESPECT TO THE FOLLOWING PARTICULARS?

(a.)—Electrodes permanently sealed.

(b.)—Electrodes capable of being inspected at every part.

1. Preservation of insulation.
2. Expense of insulation per unit of length.

3. Avoidance of induction.
4. Speed of signalling; *i. e.*, capacity for rapidity of charge and discharge of conductor.
5. Cheapness of plant and maintenance.
6. Ease and cheapness of laying and taking up.
7. Facility for expansion. (Increase in number of conductors singly or by groups.)
8. Rapidity of repair.
9. Durability.
10. Safety of wires from stroke by lightning.

EXHIBITS OF UNDERGROUND CONDUITS FOR ELECTRICAL CONDUCTORS.

(From the Official Catalogue, page 79.)

Continental Underground Cable Co. Models of Underground Conduits. (No. 5, North Gallery.)

Woodward, Jas. S., Phila. Woodward's Curb Conduit for Electric Conductors and Steam Heating Pipes. (North Gallery.)

Hendley, Wm., Washington, D. C. Wooden Conduit for Electric Conductors. Water-color illustration of above conduit system. (East Gallery.)

American Underground Electric Wire Co., New York City. Howe system for insulating electric conductors and cables, applicable to underground systems. Apparatus for designating wires in conduit systems. (West Gallery.)

The Anderson Conduit. (North West Gallery.)

American Sectional Electric Underground Co., Phila., Pa. Underground conduits and man-holes with telegraph, telephone, and electric light and power wires, showing this system of underground conduits for electric wires in operation. (L. 11-15.)

Edison, Thos. A., New York. Samples of Underground Conducting System, employed by the Edison Company. (N. 3-6, S. 3, U. 6, A. 3-6, D. 3-6.)

The Edison Exhibit of the Combined Edison Companies, New York City. Edison System of Underground Electric Conductors, with junction boxes, couplings, etc. Insulating compound. Insulating tape. (See above.)

Brooks, David, Philadelphia, Pa. The Brooks System of Underground Conduits for Electric Conductors. (Main Building, U. 14.)

National Underground Electric Co., of Newark, N. J. Full-sized model of the Conduit for Telegraph, Telephone and Light Wires, with testing station, etc. (Depot South Porch.)

Cosmopolitan Underground Telegraph, Telephone, and Electric Light Co., Camden, N. J. (Annex.)

Continental Underground Cable Co., Camden, N. J. System of underground conduits for electric conductors, including electric railway through centre of conduit for transmission of mail, packages, etc. Pipe System of Underground Conduits. (Annex.)

Union Electric Underground Co., Chicago, Ill. Conduit for Electric Light, Telegraph and Telephone Wires. Insulation and ground connection for wires. Machines for introducing wire into insulating tube. (Depot, N. Porch.)

THE AMERICAN SECTIONAL UNDERGROUND COMPANY.

(*" A. b." of Section's Classification.*)

This system consists of cast iron conduits, built up in sections breaking joints; the joints being secured with clamps and keys, and cement or other packing. All parts of each particular size are interchangeable. The conduit contains interchangeable metallic shelves and partitions, dividing it into compartments for carrying wires of different kinds.

Three sizes of conduit were exhibited, each being connected to a manhole placed at every street corner, into which one or more men can enter for the purpose of hauling in the wires, making the necessary connections, etc. There are further, at convenient distances along the line of conduit, handholes for tapping the wires for house-to-house supply. As the position of these is accurately known, by opening up a few stones in the pavement a wire or wires can be tapped for house supply. This is effected by running the wires required from the nearest manhole on the upper or local shelves.

Different companies can be supplied with separate compartments, and they can employ any particular insulation they prefer.

It is claimed for this system that "a metallic contact between the insulation of all wires and the earth grounds all leaking or induced currents, overcomes induction to a great extent, and renders harmless a cross in an electric light current. Further, that by the use of the copper shelves, in conjunction with telephones on metallic circuits, there is absolutely no interference whatever."

The committee was unable to satisfy itself on all these points.

The conduit when opened appeared to be very dry. It is stated that all condensation of moisture in the conduit takes place only under the manhole covers, which are exposed to the external air. This seems to be borne out by observations on the 9th of October, 1884, no rust being visible.

This system seems to meet, in a very complete way, the question of house-to-house supply; separation of wires; facility of laying; repairs; and future expansion. It is not necessary to lay the wires in the conduit until absolutely required. It would, however, be necessary to use first-class insulated wires, as it would not be possible to keep such a conduit absolutely dry. Some provision will also have to be made for passing off gas, which tends to accumulate in the main, and might be set on fire and prove dangerous. It is estimated that the *A* conduit, 10 inches by 15 inches, would cost $15,000 per mile, the *B* conduit, 6 inches by 10 inches, $10,000, and the *C* conduit, 5 inches by 8 inches, $5,000. The *A* size of conduit, which is laid in Chestnut street, Philadelphia, from Third to Broad (equivalent to Fourteenth) streets—(about a mile in length)—is estimated to accommodate 3,000 wires. The *B* size is laid in Tenth, Eleventh and Brown streets, and its capacity is for about 1,200 wires.

By means of the large manholes and separate compartments, the wires in use can be at any time taken out, replaced by others, or inspected and put back, in the shortest time and with no derangement to the pavements and streets. The size of the conduit also enables one to lay a very large number of wires. The prevention of induction would seem to be about equal to that in all systems employing iron-cased ducts, with the additional advantage of interior metallic screws and copper shelves, all well grounded, so that no current in one compartment would be likely to have any influence on those of another.

The conduits were laid down along Chestnut street in October, 1883, and the electric light service has been continuous since the latter part of December of that year, which period included a number of severe storms, of longer or shorter duration.

It has not been ascertained that any interference with the service has been suffered. The weather during the continuance of the exhibition was unusually dry, and, therefore, though the interior of the conduits was dry wherever seen by the examiners, this would not establish the fact of the successful exclusion of moisture by this system under unfavorable circumstances. On this point the undersigned have been compelled to take the testimony of the officers of the company and the statements of the subscribers as to the success of the conduits for the electric light wires.

Few, if any, telegraph or telephone wires were in the conduits, and as it is with these that the defects of any system would be best observed, the examiners have no sufficient data for expressing an opinion.

It is the intention to introduce these insulated telegraph and telephone wires loosely, or without any casing, unless there be a long distance in which no service is ever to be made. Under these circumstances the company proposes to use a cable. Otherwise, the wires are to be laid loosely over each other in their various compartments.

A question which is intimately connected with the conduit itself is that relating to the exclusion from it of foreign matter, and especially of water. [The company has suffered from gas in its conduits, and on one occasion an explosion ensued in a manhole near the State House, but this latter caused no serious damage, and it is not thought likely that there are many localities where these conditions of gas waste under the streets are likely to be similar.]*

In the streets of a city where there were great differences of level, any considerable break in the conduits which would permit the influx of a large body of water might (if the latter found free path) do considerable damage. This is an objection applicable to all hollow conduit systems.

Open gratings have been employed to permit the waste gas to dissipate itself, and these gratings have often remained open during both snow and rain storms without introducing moisture into the main conduits, the water escaping by a trap at the bottom of the manhole.

So far as the renters of the light are concerned there is not the least danger of the introduction into their houses of water or gas from this company's conduit, inasmuch as the electrodes are hermetically sealed in a gas pipe which leads them from the handhole.

A telephone wire is laid down in the conduits, leading from the company's central office, in Eleventh street, to Broad and Chestnut streets corner. This was tested in the daytime, when the electric light currents were not passing. The terminal instruments were also out of order. The committee cannot, therefore, say what may be the effect of the electric light current on the telephone lines from this observation.

The following is a description of the figures in the cut:

Fig. 1 represents a longitudinal elevation of various sizes of conduit *A*, *B*, *C*, with vertical sections through "manhole," *d*, *e*, *g*, and "flush box," *b*, showing mode of laying and connecting them.

Fig. 2, plan view of same.

Fig. 3, isometrical view of section of *A*, conduit, and hand-hole, *c*, *j*, showing joints of upper and lower sections of conduit, *K*, *K*, partitions and shelves for electric wires, the "static condensing shelves" being shown by dotted lines.

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* This report was completed on October 30, 1884.

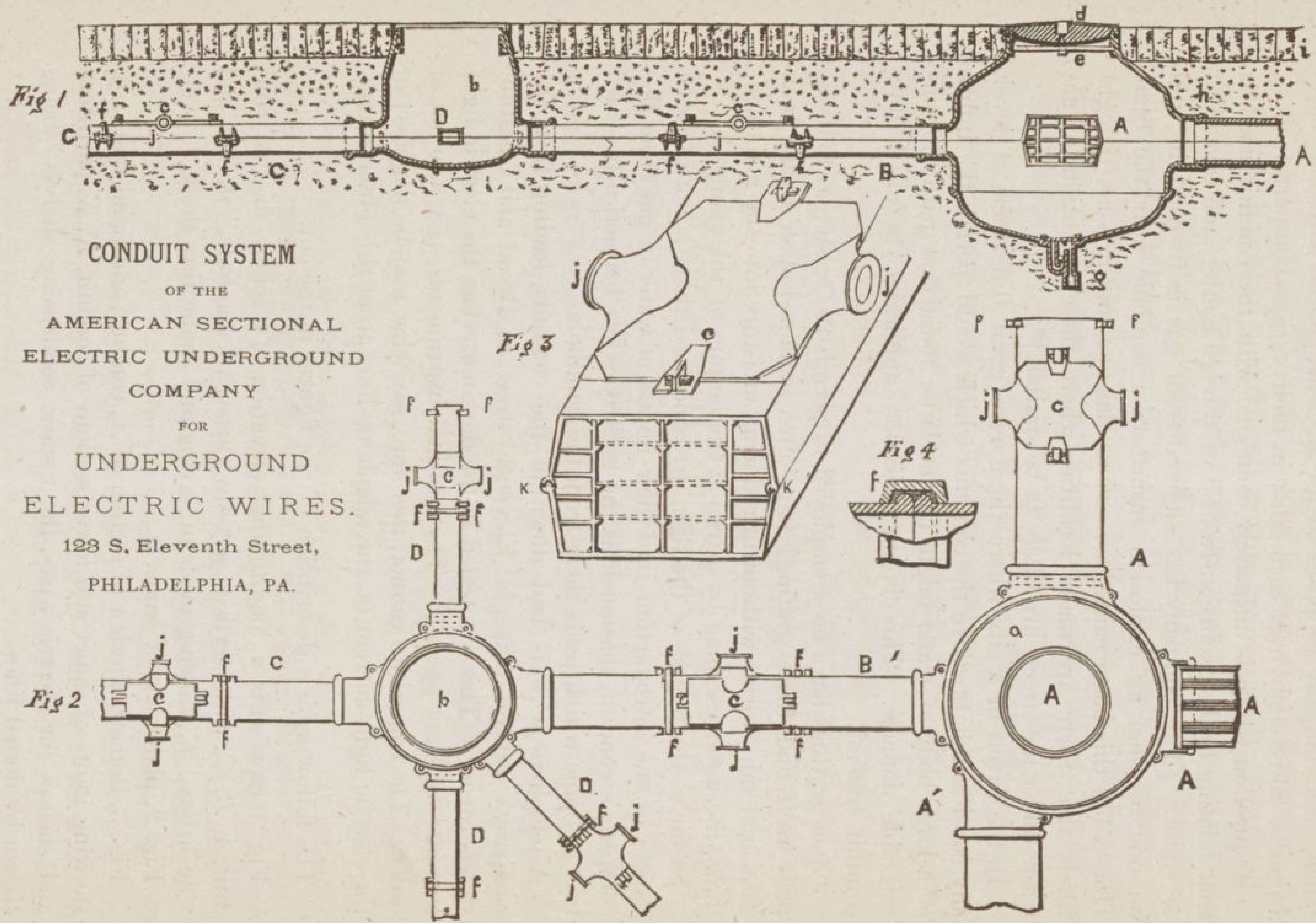
Fig 1
Fig 2
Fig 3
Fig 4
b
D
A
B
C
c
d
e
f
h
i
j
k
a
A´
B´

CONDUIT SYSTEM

OF THE

AMERICAN SECTIONAL
ELECTRIC UNDERGROUND
COMPANY

FOR

UNDERGROUND
ELECTRIC WIRES.

123 S. Eleventh Street,
PHILADELPHIA, PA.

Fig. 4, tranverse section through top of clamp, showing section of ends of conduit and packing at joints.

The letters show similar parts in the different figures, *A* being the largest size conduit yet made, capacity about 3,000 wires. *A′*, showing the conduit opening in manhole when connection is made at one side of manhole or flush-box. *B*, *C* and *D* are consecutively smaller sizes of conduit; *a*, manhole, *b*, flush-box, *c*, handhole, *d*, manhole and flush-box cover made either solid, or perforated for ventilation; *e*, bar with which to fasten cover by aid of bolt and nut; *f*, clamp and keys by which the different sections of the conduit are connected; *g*, trap for drainage of any water which may collect in the manholes and flush-boxes from rain or condensation, and which may be connected with sewer; *h*, street-bed, earth and gravel; *i*, street paving; *j*, handhole opening for house connections; *k*, longitudinal joints between upper and lower sections of conduit, to be filled with any suitable packing to exclude moisture, etc.

THE ANDERSON CONDUIT FOR UNDERGROUND WIRES.*

(*" C." of Section's Classification.*)

This conduit is constructed of cellular section and of any suitable material, such as iron, terra cotta or glass. It provides a series of ducts, into which cables or wires of different classes or belonging to different subscribers, may be accommodated. In both sides of the conduit are a series of lateral openings, formed in the process of manufacture of each length of the conduit. These openings give access to the ducts on either side, and are intended for tapping the wires at any desired point. Each side duct, on either side of the conduit, has one of these lateral openings, which are not arranged one over the other, but diagonally and in adverse directions on either side. The object of this arrangement, which appears to be the main feature of the system, is to obviate the weakening of the structure, which would result from having a row of openings one above the other.

No provision is made for manholes, and no arrangements are proposed for obviating the effects of induction, nor for keeping the duct water-tight or free from condensation.

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* Patent No. 261,979, dated August 1st, 1882.

The description and model were not sufficiently complete to enable the committee to form any opinion of the details, but the provision of a lateral opening to each side duct would have many disadvantages.

THE BROOKS UNDERGROUND CONDUIT.

(*" A. a." of Section's Classification.*)

This conduit consists of wrought iron pipes, supplied with suitable splice-boxes, hand-holes and outlets. These pipes are protected from oxidation by being laid in a wooden trough, into which hot pitch is poured so as to completely envelope the pipe. The wires to be used in this system are covered with cotton and formed into a rope or bundle, which is then covered with a textile weaving. The bundle of wires is then soaked in hot mineral oil and drawn in long lengths into the pipe or conduit. A heavy mineral oil is then forced into the pipe so as to exclude moisture, and for the purpose of maintaining a good insulation.

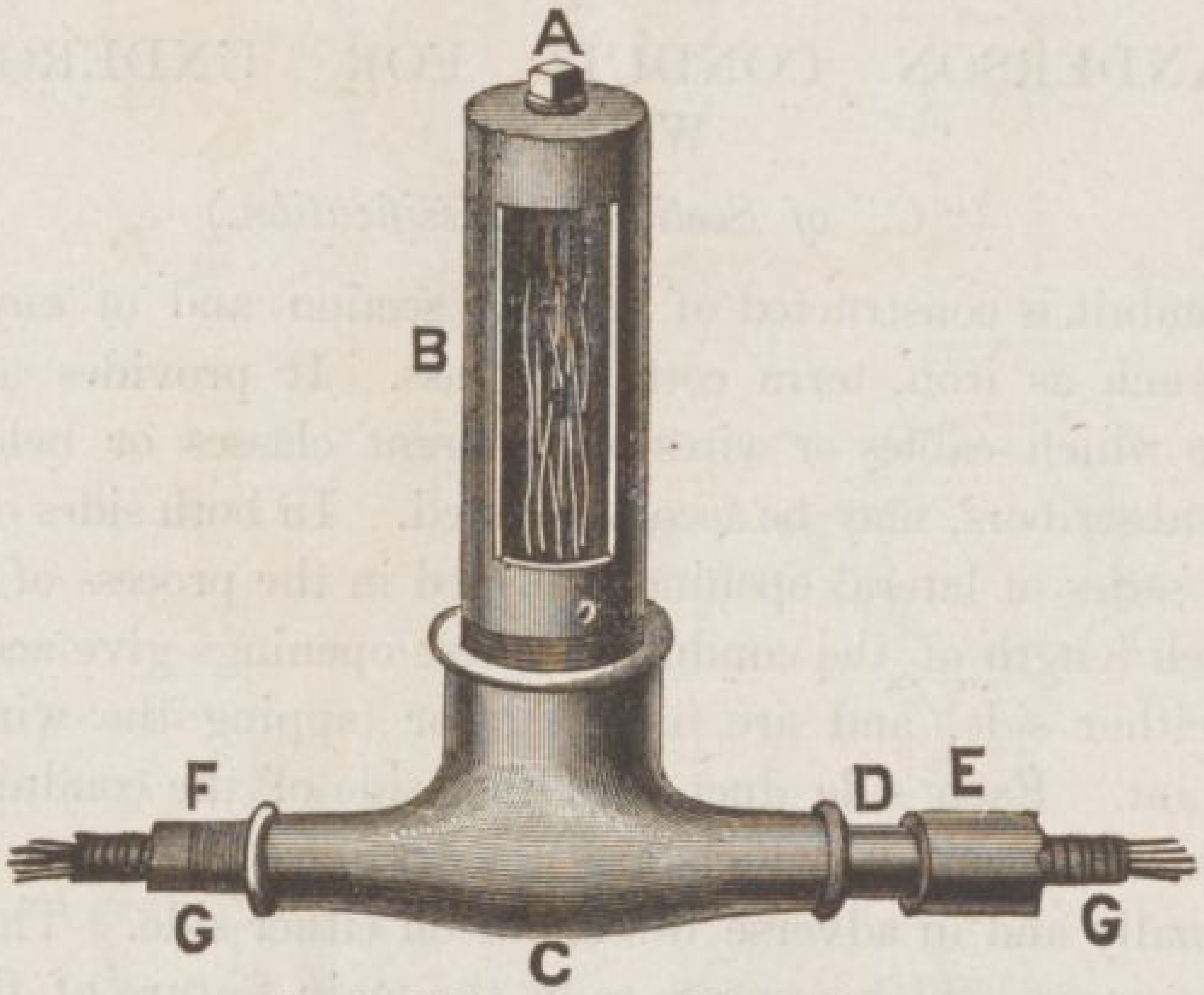


Fig. 1.—Method of making splices.

The patentee estimates the cost of laying a 2½ inch pipe complete, for house-to-house supply, with 40 conductors of No. 16, *B. W. G.* and 360 of No. 20, *B. W. G.*, at twenty dollars per mile per conductor. He states that he can lay such a conduit in one day, from block to block, so that its construction causes but little interference to traffic.

The main point of the system, is the economy of insulation. It is

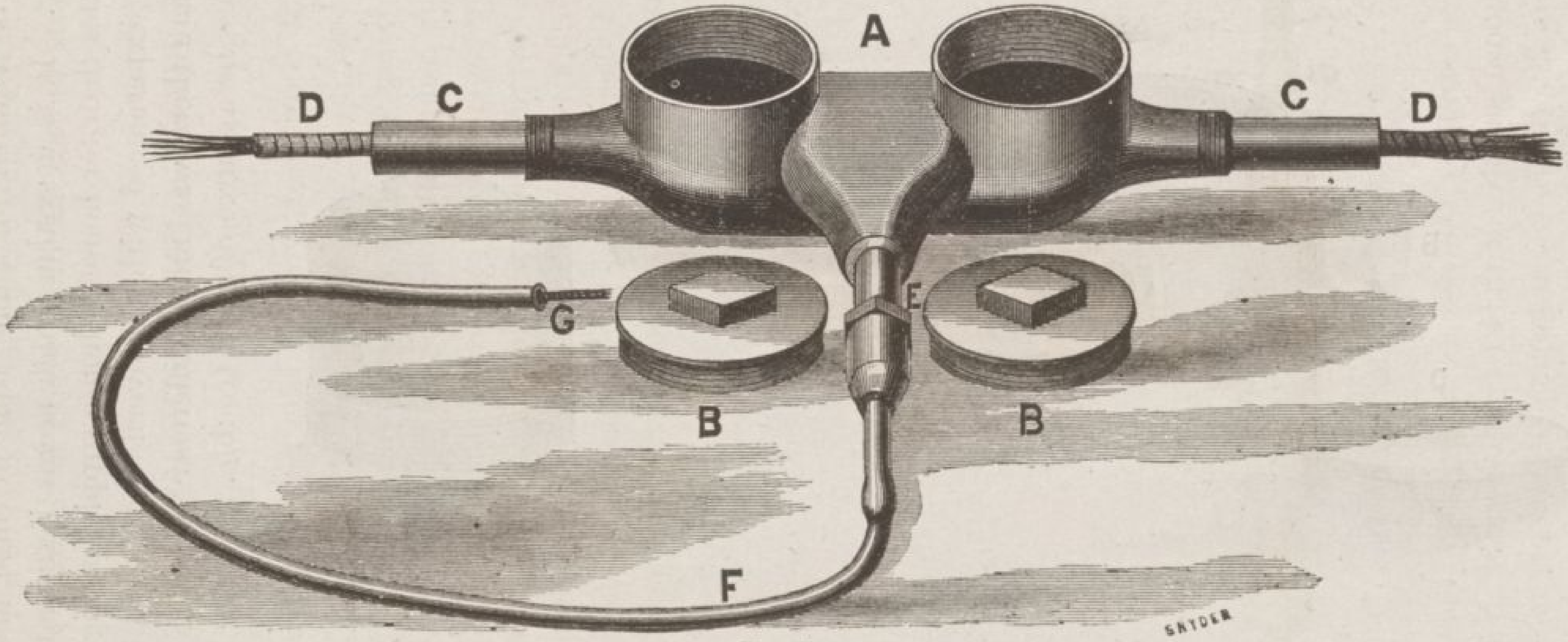

A
D
C
C
D
G
E
B
B
F
SNYDER

FIG. 2.

proposed to anticipate future requirements by laying down as many wires as may be required for a long time to come, and not to add or withdraw any. It is a system which seems better adapted for trunk or through lines than for house-to-house supply, owing to the difficulty that would be experienced with the overflow of oil at so many points. In towns where there was much difference of level the head of oil would doubtless be a source of great trouble.

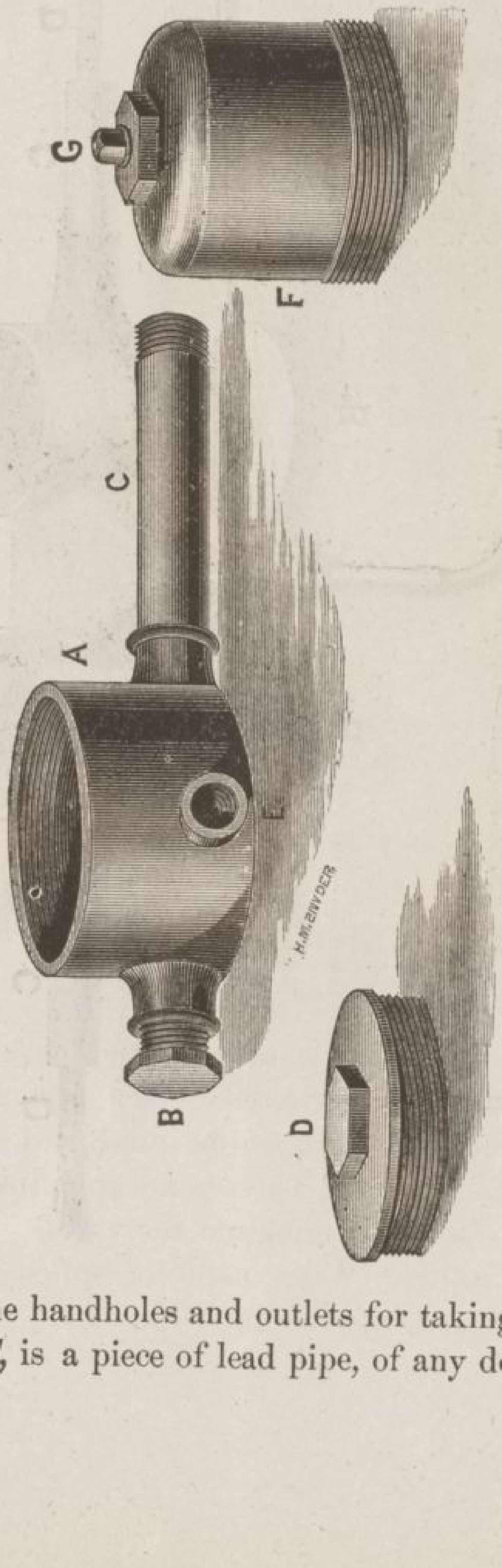


FIG. 3.

Fig. 2 shows the handholes and outlets for taking wires into adjoining buildings. *F*, is a piece of lead pipe, of any desired length, sufficient to reach the first story of the building in which the wires are to be extended or looped. The lead pipe, *F*, is filled with a heavy and viscid oil until it reaches within two feet of the point *G*, where it is spliced to india-rubber or gutta-percha covered wires. The space between the gutta-percha covered wires and the lead tube is filled with plaster of Paris and silicate of soda, which effectually prevents any leakage of the oil.

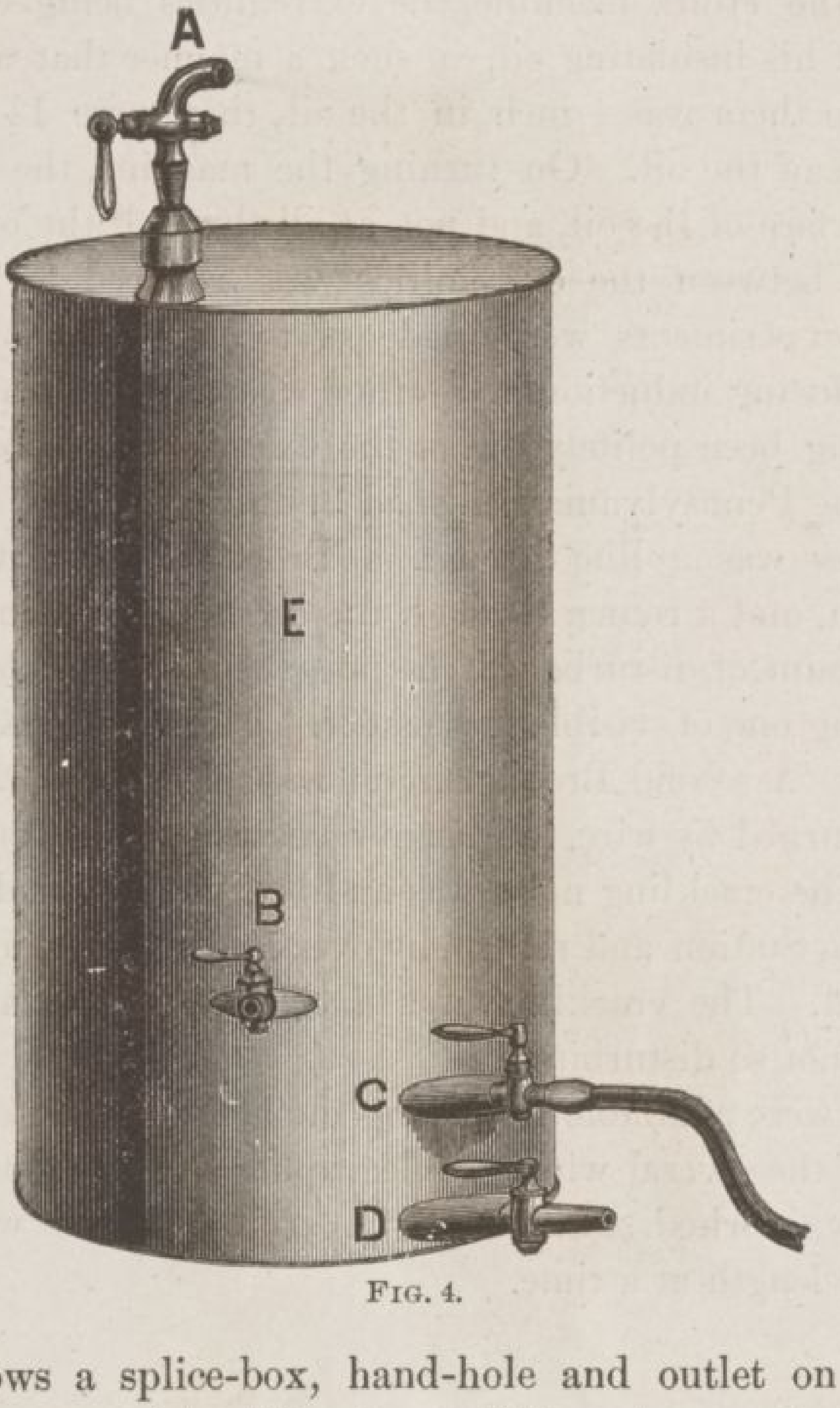


FIG. 4.

Fig. 3 shows a splice-box, hand-hole and outlet on both sides, designed to accommodate 400 wires. *C*, is a two and one-half inch diameter pipe. Reducing sockets can be introduced at *B*, for a smaller pipe and less number of wires. These boxes are introduced at intervals, fastened with plug, *D*, for bringing out the wires. The box is seven inches in diameter inside. When used for splicing the ends of the cable, dome *F* is screwed into the top of the box. *G*, is a plug in the top of the dome for pouring in oil after the splice is made. On either side of this box is outlet *E*, similar to that shown in Fig. 2.

Fig. 4 shows the tank at the Pennsylvania R. R. Station, Broad Street, Philadelphia, supplying the system with pressure and the oil lost by leakage (which is not perceptible).

As regards the efficacy of the oil, as a means of insulation, Mr. Brooks exhibited to the examiners this experiment: Two wires were attached to the Holtz machine, the extremities being carried into a narrow jar of his insulating oil, in such a manner that while the distance between them was ¼ inch in the oil, they were 1½ inches apart at the surface of the oil. On turning the machine, the spark passed above the surface of the oil, and not at all through the oil, even when the distance between the extremities was reduced to $\frac{1}{16}$ inch. A number of experiments were made as to the effect of the Brooks system in reducing induction and other disturbing elements; various circuits having been politely put at the examiners' disposition for this purpose in the Pennsylvania Railroad building.

One of these was a line through a Brooks conduit to the Broad Street Station, and a return through the earth. This line gave a considerable amount of disturbance, the noise being rather deep than loud, and reminding one of visible movement. The voice was carried clear and distinct. A second Brooks circuit was metallic, *i. e.*, the message went and returned by wire, the distance between the station being about 1¼ miles. The crackling noise was audible, but not loud or deep. A line to Merion Station and return, by overhead wire (14 miles), worked nearly as well. The crackling was *finer*, *i. e.*, shriller and more continuous, but not so disturbing.

No means were available for testing the amount of interference with each other of the several wires of telegraphic and telephonic circuits in the same tube, worked simultaneously. 2,000 feet of wire is pulled through each length at a time.

THE CONTINENTAL UNDERGROUND CABLE CO.

("A. b." of the Section's Classification.)

Description by the Company, edited by the Examiners undersigned.

This company's plans consist of two distinct systems. The first is described in figures 1, 2, 3, 4 and 5, and the second is described in figures 6, 7, 8 and 9. While it is here described more particularly as an electric lighting system, it can as advantageously be applied to wires for other uses of electricity, and is adapted to cross streets, or where one company wishes its own separate conduit. The first-mentioned system being the trunk line system, to accommodate all the different companies in one plant.

In the trunk line system the conduits are constructed with a view of keeping the dampness from penetrating them by either making the walls of asphalt or asphalt blocks (or other anti-moisture material); or by constructing the walls of bricks laid with cement mortar and covering the outside of the wall with asphalt or cement to keep the moisture out, and then keeping them constantly under pressure of dry air.

In order to use a comparatively cheap cable, the conduits are kept dry for the protection and preservation of the cables. And further, they are kept under pressure, and objectionable gases are kept excluded, as dampness or gases will not enter against inside pressure.

At first sight it may be said that there will be considerable cost attending the process of pumping dry air into the conduits, but a conduit of one, two, or three miles in length, may be kept under pressure by a very slight power from a single pump, which may be rented anywhere along the line and connection made to the conduits at a very small yearly cost to the company in conformity with the plan in the patent.

Every electric light company having an engine running to compress the air supplied at the generating station for the tubes containing their own wires, as shown in Fig. 6. The principal object in keeping the wires and conduits under dry air pressure is to prevent the escape of electricity from the wires, or reduce the escape to a minimum. While this principle is adapted to telegraph and telephone wires, it is particularly adapted to underground electric light wires, where very heavy currents are passed; for on long circuits the lights on the farthest end of the line or circuit burn dimly and are incapable of giving that brilliancy of illumination for which they are designed, unless the intensity of the electric current is greatly increased over the normal, and this is injurious to the lamps near dynamo electric machines and requires a greatly increased expenditure of power used in the generation of the current. By the use of the means employed by this company to retain the full force of the electric current, it is claimed that the distant lamps burn as brilliantly as those near the generators, and all burn with a maximum brilliancy without increasing the intensity of the current over the normal, and with a minimum expenditure of power. The accomplishment of this result depends mainly upon two phenomena, viz., the absorption of the moisture from within the conduits, by chemically dried air (the moisture rendering the air a good conductor), and increasing the pressure or density of the air around the conductors and within the conduit, by mechanical means, the same preventing the free escape of electricity from the wires.

The conduit should be made practically air-tight, with an air compressor at one end adapted to constantly force air into said conduit under pressure, and apparatus to contain an absorbent for the extraction of the moisture from said compressed air, and an escape or pressure valve adapted to remain closed until the desired pressure of air is obtained, and attached to the conduit at its other end or at different places along the conduit, and when the air compressor is put in motion to force a constant current of air under pressure into the main and out through said relief valves, and thereby insure a perfect circulation of chemically dry air under pressure.

The greater the pressure or more dense the atmosphere, and the more free the air is from moisture; the less liability is there for the escape of electricity, and *vice versa*, to follow a natural law which has been demonstrated, the more rarefied the air around an electric wire and the more moisture it contains, the more freely will electricity escape from the wire. By this process every part of the space within the conduit (not occupied by the wires or their covering) will be occupied by compressed or dense dry air. The insulation should be perfect, as there will be no space so small that the compressed air will not instantly penetrate it. In the case of electric light wires, they will be supported within a tube by glass or porcelain supports, as represented in figures 7 and 8, and each wire having an air space surrounding it, the dry compressed air will encircle each wire and insulate it perfectly from all others. A slight insulating covering as an extra precaution should be used on the electric light wires also.

One of the simplest forms, system No. 1, is shown in Fig. 1. A conduit for one or more cables of wires is arranged on either side of the track to accommodate, combined, 800 wires.

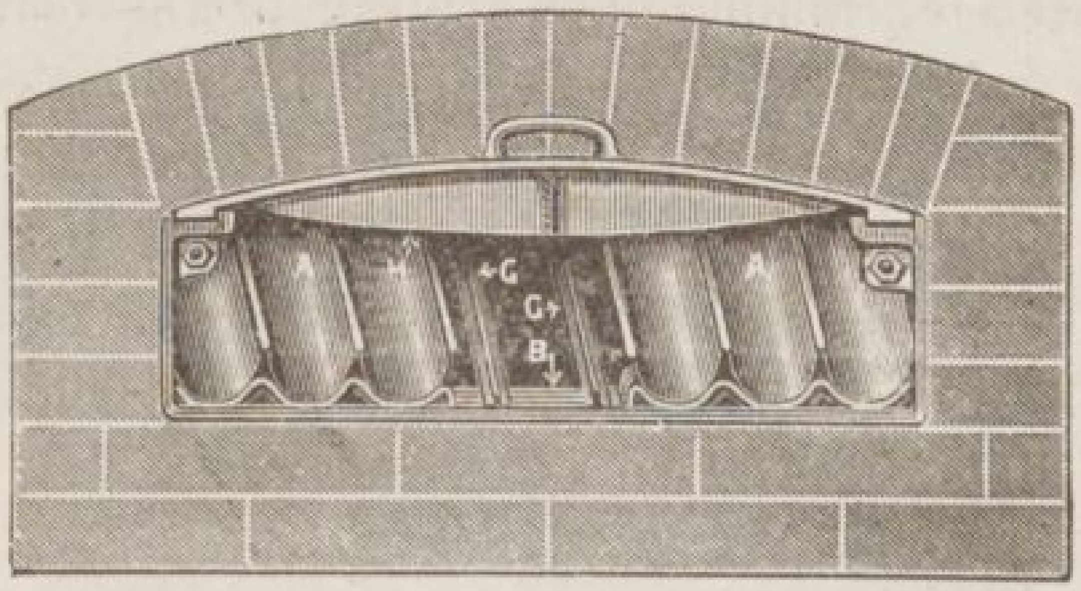


FIG. 1.—Inside measurement, 4½ x 17 inches. Capacity, 800 wires.

That shown in Fig. 1 will probably be sufficient for any one company for many years to come, but where more wires are required the capacity of Fig. 2 should be had, and any single company will probably never require on any street more accommodation for wires than can be had by the conduit shown in Fig. 1, but should a greater capacity be required, the construction shown in Fig. 2 may be used, in which it is seen that pockets are arranged in a manner similar to that shown in Fig. 1, but two deep. In place of arranging pockets as shown in Fig. 2, they may be arranged as shown in Fig. 3; in which the pockets are arranged in single rows, one above the other, four deep.

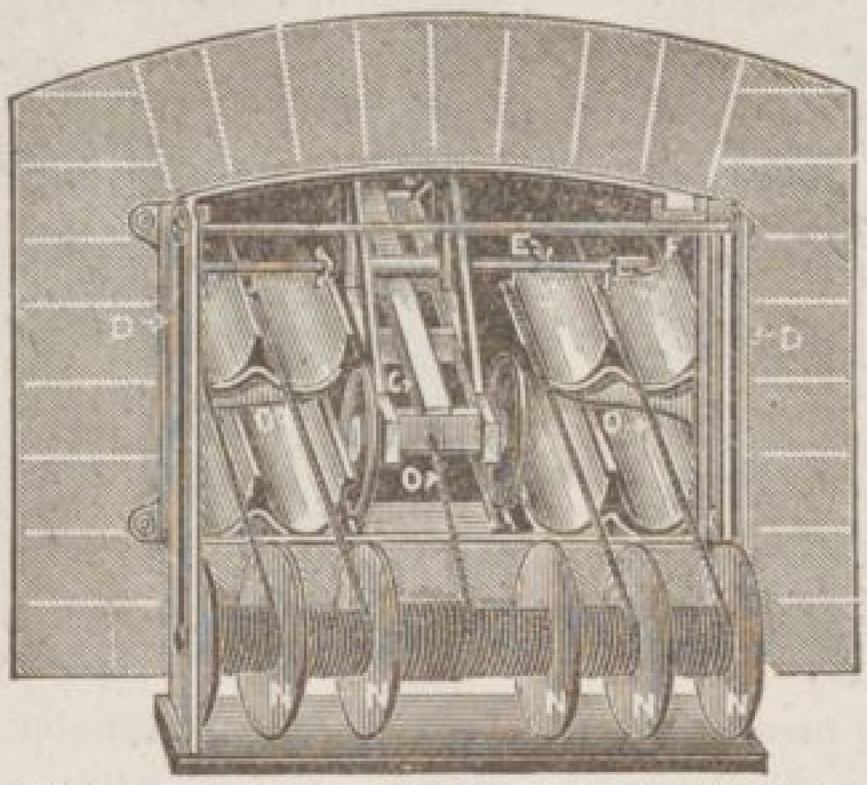


FIG. 2.—Inside measurement, 9 x 17 inches. Capacity, 1,600 wires.

Figs. 4 and 5 show the system for laying wires on a larger scale, and which is especially adapted to accommodate a number of separate companies. Each of said figures show the same capacity with but a slight difference in construction, the arms supporting the pockets in Fig. 4 uniting both uprights and a track is furnished to each apartment of six pockets; while in Fig. 5 the arms or brackets do not thus unite, but leave a vertical passage way from top to bottom of the conduit wherein the motor or carriage, running upon the rail of the bottom, causes its adjustable arms to travel when in the act of laying the cords, wires, or cables in the various pockets upon either side of said passage way. For an entire city only one motor and one carriage will be required, or if the process of laying the wires is to be carried on by either the carriage or motor alone, then the one or the other may be dispensed with; the pockets are made semi-cylindrical, three inches wide at the top and an inch and a half deep, or they may be made nearly cylindrical with a slot on the upper or top side running the whole length to admit of the chain or cord being laid in the pocket by the car with which to draw the cables into position. The space for the motor is between five and six inches wide, but reduced to two inches above the railway, and as it extends from the bottom to the top of the conduit, access to the

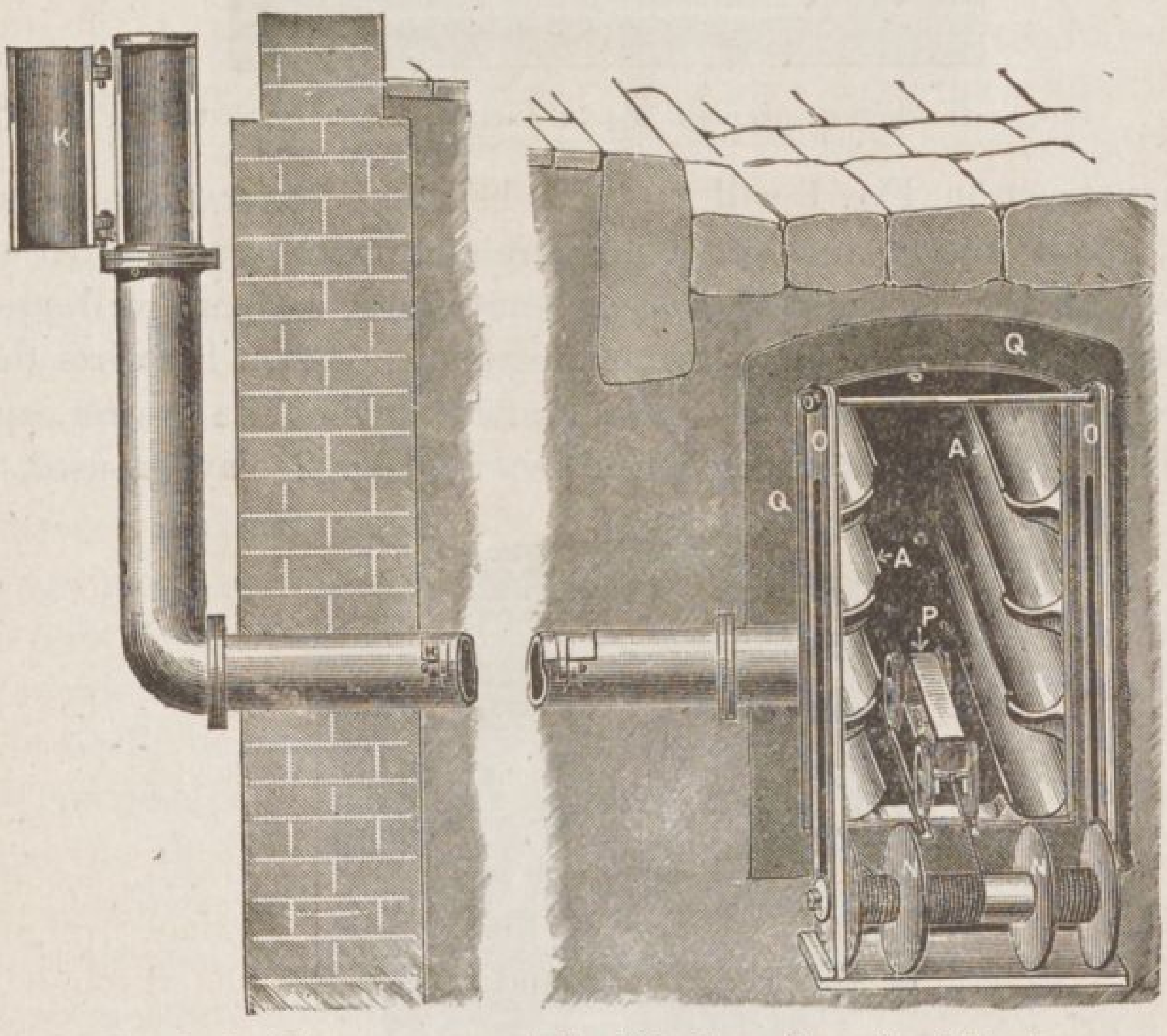


FIG. 3.—Inside measurement, 11 x 18 inches. Capacity, 1,600 wires.

cables without removing them from their pockets can be had from the top if at any time it should be desired or become necessary.

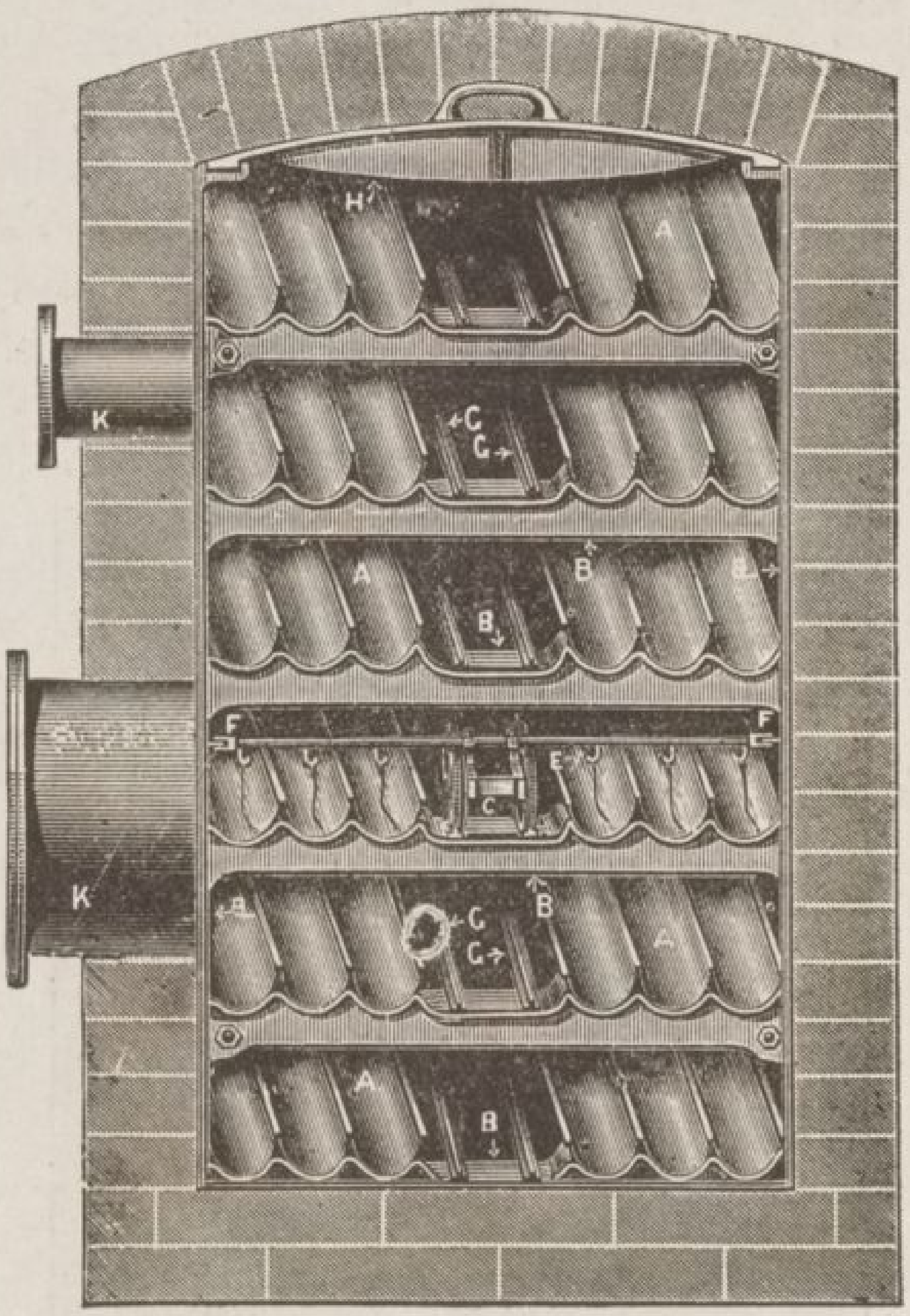


Fig. 4.—Inside measurement, 23 x 27 inches. Capacity, 7,200 wires.

A vertical space of one to two inches is left between the upper and lower pockets to enable the passage of the motor or carriage arm and also to enable the cable to be tapped and the wire taken through an outlet. (See *K*, Fig. 3.)

Service from the conduit to houses may be made by a connection run under the sidewalk and into the cellar, as shown in Fig. 3, conveying wires through said pipe into the houses. The conduit before each house is provided with a plugged branch, which may be opened for connection when required.

Where a number of companies are using the construction shown in Fig. 4, each of said companies can place a suitably arranged lock against admittance to their respective apartments.

Fig. 3 shows an electric motor in the act of drawing a cord or wire cable from a spool supported by an adjustable upright, temporarily placed in a manhole for the purpose; this cable when laid, being adapted to draw the carriage through, which in turn lays a series of cords or cablès in the various pockets, as shown in Fig. 2. If it is required that the carriage make two or more trips successively, then the carriage, in being drawn through, may also draw through an additional cable (see Fig. 2), by which said carriage may be returned after laying the first lot of cords or electric cable, and be in readiness for a second supply

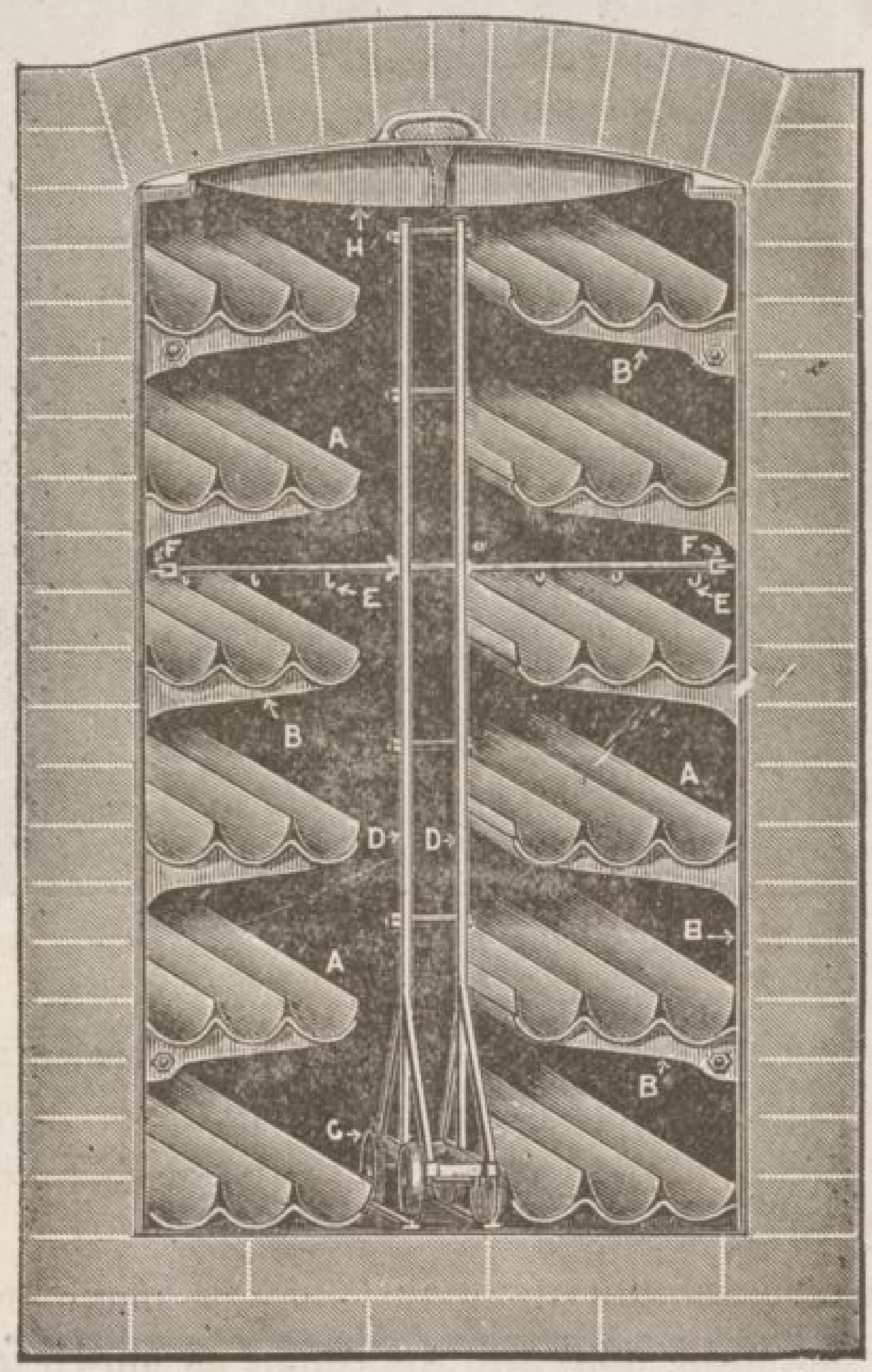


FIG. 5.—Inside measurement, 23 x 27 inches. Capacity, 7,200 wires.

The plan is to place the largest number of wires in the smallest possible space after allowing for space to conveniently get at the wires, lay and relay them, for taking them off to houses and for circulation of dry air, etc.

The walls of the conduit may be built of blocks made from asphalt compound, by an improved process, whereby it becomes impervious to moisture, and possesses great strength; and the metal uprights, brackets, and pockets, are connected with the earth to carry off induced electric currents to the earth. By this construction the conduit can be built more cheaply than if constructed entirely of iron, and in addition thereto, is not so apt to become electrically charged.

The cylindrical sheet-iron pockets are formed by machinery and in sections of four to six feet long, the ends of which are turned, to receive the supporting brackets, which clamp said pockets end to end. The uprights and brackets are bolted together in a manner as to clamp firmly the ends of the pockets, thus uniting the adjacent sections, and thereby securing a substantially smooth pocket or trough extending from one manhole to the next, the smooth surface overcoming any danger of injuring the cables in the act of drawing them through, and at the same time decreasing the labor. The uprights and pockets with the railway are fitted in the machine shop, and several sections, secured together, are lowered simultaneously to the foundation made for it in the street. These are then closed in and the conduit is complete.

It is estimated that the system just described can be laid with a capacity of 12 to 15 pockets adapted for different companies to occupy separate pockets for their own wires, each pocket having a capacity of 100 to 200 wires (according to the kind of wires or cables are used), for from $8,000 to $10,000 per mile, depending upon the material used in the masonry.

Fig. 6 represents a general view of our electric lighting system in which we have to deal with currents of electricity of high electro-motive force. In such systems in moist weather, or even owing to the dampness of an underground conduit, there is an escape of the current and this materially reduces its tension so as to render the current incapable of producing a light of more than small candle power at a short distance from the generating station. This has been one of the obstacles to placing electric lighting wires under ground where the current was to be conveyed over long distances.

By this system the tension of the current is retained at its maximum, and so far as dampness is concerned the tension is unaffected, thereby conveying currents underground over even longer distances than can be done above ground, under the ordinary variations of the hygrometric state of the atmosphere.

To attain this end the air within the conduit is kept under consider-

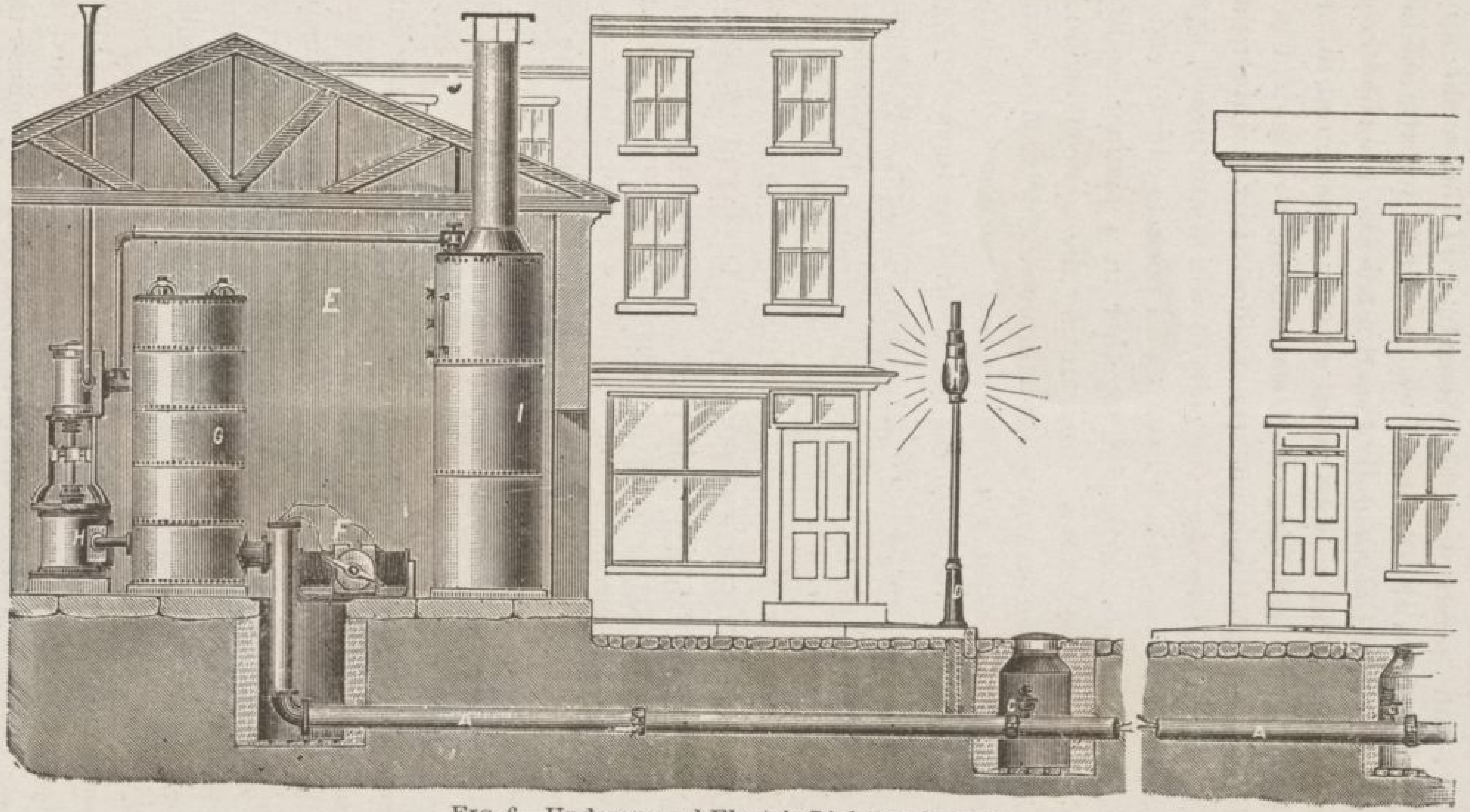


FIG. 6,—Underground Electric Lighting System, able pressure, and perfectly dry. If there is any appreciable amount of moisture in the atmosphere, the air-pump *H*, forces the air first through a dryer *G*, which absorbs all the moisture, and the chemically dried air passes into the conduit *A*, and when the pressure becomes over a fixed amount, the relief valves *C*, allow the excess of air to pass off, thus keeping the pressure in the conduit uniform. Currents of high tension tend to pass off the conductors, but this tendency decreases as the pressure of the surrounding medium (air) increases, and this effect is greatly increased by the thorough drying of the air in damp weather before passage into the conduit. The drying chemicals may be used over and over again, and the system is adapted to any substantially air-tight conduit. As the pressure is constant there must be an efflux, and should there be a small leak the passage of air will be from inside outward, thus preventing ingress of moist air.

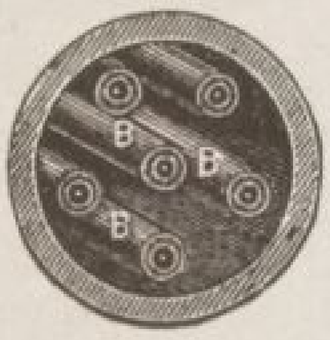


Fig. 7.

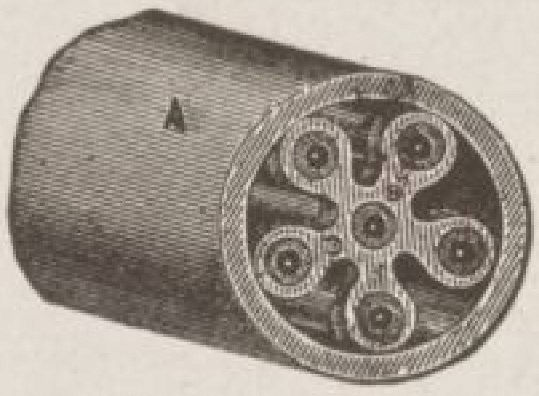


Fig. 8.

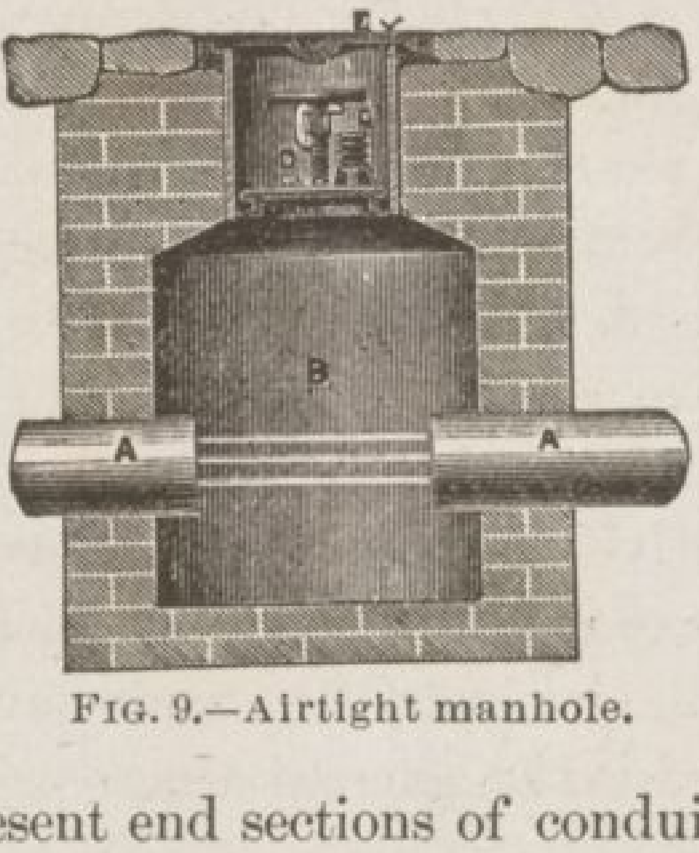


Fig. 9.—Airtight manhole.

Figs. 7 and 8 represent end sections of conduits for electric lighting purposes, in which *B* are the conductors and *A* a metal pipe, the conductors *B* being supported by suitable insulators within said pipe. The conduit *A*, Fig 6, may be continuous with testing doors in the manholes *B*, or if desired the conduit *A*, may be open on the ends where it enters the manhole; as shown in Fig. 9, in which the door *D* is made air-tight and covered by an auxiliary cover *F* on the road, the said door *D* being provided with the relief valve *C*. In this construction the manhole is filled with compressed air.

This principle may be applied to general conduits, which may also carry the electric light wires, or instead of supplying the whole conduit with compressed air the electric light wires may be enclosed in leaden or iron tubes, and when laid in the conduit, air may be forced under pressure through said pipes.

Comments by the Examiners.

While the system just described is more particularly intended for electric light wires, and if applied successfully to currents of high tension, it can more easily maintain a good electrical condition for telegraph and telephone wires; and a pipe conduit 3½ inches in diameter can be laid for about $3,000 per mile, and will contain at least 300 wires.

If absolutely dry air could be maintained in this conduit, no doubt it would be attended with many of the advantages claimed for it. But it would be exceedingly difficult to ensure in any conduit of masonry, however carefully built, absolute immunity from moisture, and to keep such a conduit, with its many manholes and outlets under air pressure, would, it is thought, be quite impracticable.

The employment of an electric motor to run a cord or chain through the duct for the purpose of feeding in the wires appears to be a refinement which, to say the least of it, lacks simplicity. Further, the expense of maintaining dry air under pressure by a separate apparatus would be an expensive process both in first outlay and subsequent maintenance.

The employment of dry air, however, in wrought-iron pipes has obvious merits as a cheap and manageable insulator and is well worthy of being developed. The details of the system have not yet been worked out, and the models exhibited showed a new principle, but not so far a practical system.

The COSMOPOLITAN UNDERGROUND TELEGRAPH, TELEPHONE and ELECTRIC LIGHT COMPANY of NEW JERSEY.

Patented May 8, 1883.

(*"A. b." of the Section's Classification.*)

This conduit is constructed of highly glazed terra cotta, in sections two feet in length, with a tap joint on the top and ends, and is bedded on a cast iron or terra cotta base plate.

Its interior is fitted with iron frames, placed at suitable distances apart, which clamp large plates of some suitable insulating material, such as glass. If bare wires be used, they may be drawn directly through the holes, but where insulated wires are employed, the openings should be fitted with short sleeves of porcelain or glass, to prevent the insulation being injured.

Some of the sections are fitted with tubular projections for tapping the wires, wherever required, for house-to-house supply.

Cast iron manholes are placed at suitable intervals.

The slack of the wires is taken up every fifteen feet, and the wires are then clamped.

All the joints are carefully cemented in order to exclude moisture.

It is stated that about one hundred yards of this system has been under trial in Fourth street, Camden, N. J., and that the cost will not exceed one dollar per foot run.

No provision is made for overcoming the effects of induction in telephone wires. After the duct has been laid and filled with wires, no addition or alteration to the wires can be made without laying open the street down to the level of the base of the conduit and remaking all the joints.

THE ELECTRIC TUBE COMPANY.

UNDERGROUND CONDUCTORS.

Statement of the Company, edited by the Examiners undersigned.

The essential form of the conductors exhibited by this company is that of an iron tube containing one or more copper conductors insulated from each other and the enclosing iron tube, and having all remaining spaces in the latter filled with an extremely viscous, almost solid, insulating compound, which becomes fluid at a high temperature. This manufactured product is termed an "Electric Tube." These tubes are manufactured in fixed lengths, generally twenty feet. The conductors project from two inches to three inches beyond the end of the enclosing iron tube, and two lengths of electric tube are joined together by means of copper joints soldered to the projecting conductors and so formed as to allow the expansion of the conductors to take place without injury or danger. Such joints are protected by a cast iron box completely enclosing them and securely fastened to the ends of the tubes enclosing the conductors. This box is then filled with the same compound as the tube and hermetically sealed.

The exhibit of this company showed the great range in the size and number of conductors which the fundamental form of cased conductor permits, and the great flexibility in making circuits of complicated ramifications, which is given by the plan of having joints at frequent intervals; and the methods of making these joints.

To illustrate the range in size, etc., samples of electric tubes were shown containing conductors varying in number and size, from a single round conductor 1·61 inch diameter, of 2,592,100 circular mils. or 2·036 square inches sectional area, in an iron tube 2⅞ inches outside diameter, to 271 wires No. 14 Brown & Sharpe gauge, of 4,100 circular mils. or ·00322 square inch sectional area, in an iron pipe 3¼ inches outside diameter.

To show the manner in which circuits of a complicated character may be made with this form of conductor, circuits such as those used for incandescent lighting on a large scale, having a large number of derived circuits with conductors of widely differing sizes, there was exhibited a portion of an underground circuit such as is used in T. A. Edison's 3-conductor system of incandescent lighting—a system using tubes of which the cross section is shown by Fig. 1.

This exhibit consisted of, first: a "Junction Safety Catch Box." This is a large round box the top of which is flush with the surface of the street; it is provided with a loose outside cover, and a lighter inside cover bolted down to make a water-tight joint with the box; these being removed, disclose the internal electrical connections in a readily accessible position, six inches below the surface of the street. The central portion of the box is occupied by the "Pole Pieces," consisting of as many rings as there are conductors in the system (in this instance three), each ring having as many radial projections as there are tubes entering the box (in this instance six), these projections, which are symmetrically arranged as regards polarity, are all brought to the same level at their extremities and terminate in plane, polished, gold-plated surfaces one inch square, which are arranged equidistant from each other in a circle around the centre of the box. Each of these surfaces has a tapped hole in the centre.

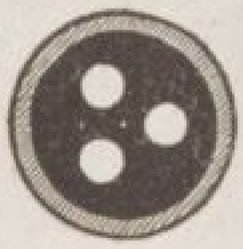


Fig. 1.

In a circle outside the pole pieces, are as many "Safety Catch Joints" as there are conductors entering the box (in this instance 18), these safety catch joints are arranged radially opposite the extremities of the projection of the pole pieces; each consists of a copper or composition piece which has a copper rod soldered into it projecting about eight inches downwards into the body of the box, the upper end of the composition or copper piece terminating in a plane, inch-square, gold-plated surface, the same as those on the pole pieces. These surfaces of the safety catch joints are on the same level as the similar surfaces on the pole pieces, and radially opposite and equidistant from them.

Two feet below the top of the box (that is the surface of the ground) the electric tubes (in this instance 7) enter the box and are rigidly attached to it, the joint being made water-tight. The pole pieces and the safety catch joints are all insulated from each other, but rigidly attached to a support rising in the centre from the bottom of the box.

Flexible copper cables join each conductor, of each tube, with one of the copper rods which project downwards from the safety catch joints, so that by means of flat safety catches placed across from the safety catch joints to the corresponding projections of the pole pieces, all conductors of like polarity are joined together at this point with a safety catch in each circuit in a readily accessible position, where it can easily be removed or replaced. Such a box equalizes the electromotive force at that point of all lines entering it, or if one of the tubes is a feeder, that is, runs back to the dynamos, the box is a distributing point for several circuits which may or may not be brought together again at some other place.

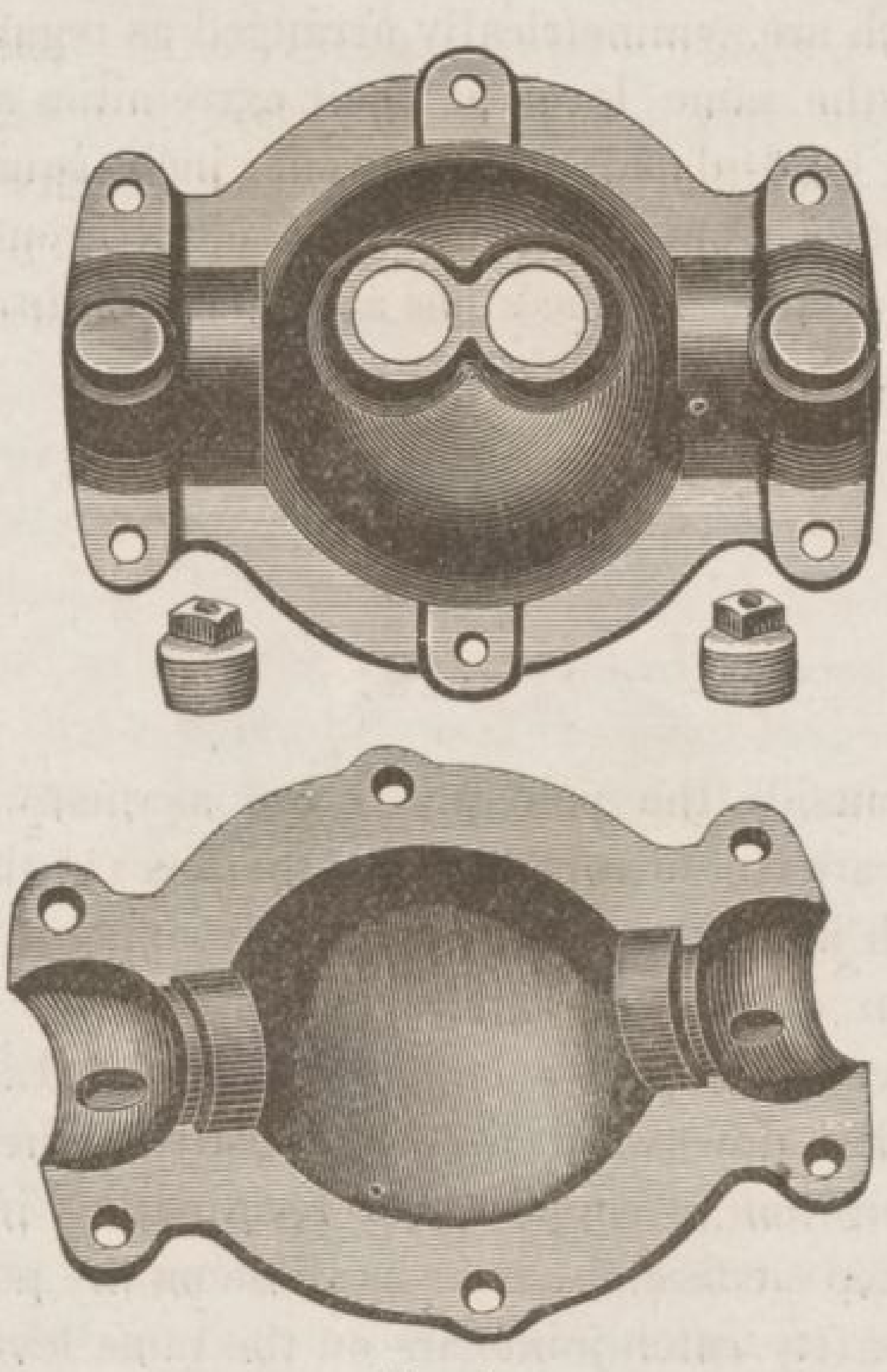


Fig. 2.

The conductors in the tubes entering this box may be of any size to suit the requirements of the different circuits. The circuits shown entering this box vary from 350,000 circular mils. to 133,000 circular mils. area of conductor, and are arranged to show how they may be laid, bent in different degrees to right or left, joining each other at their extremities; crossing each other and joined together at the crossing; joining other circuits at any point in the length of the latter;

reduced in size at any point of their own lengths, and having derived circuits of any size taken from them at any point of their own lengths; and having all these varied connections of different sized conductors made by means of a comparatively small number of standard patterns of connecting joints, boxes covering the joints, and ball clamps attaching the boxes to the iron tube enclosing the conductors.

The ball clamps, in connection with the boxes, are essential features of all underground conductors of this company's exhibit.

Figs. 2, 3 and 4 illustrate the forms of these parts and the manner in which they are used.

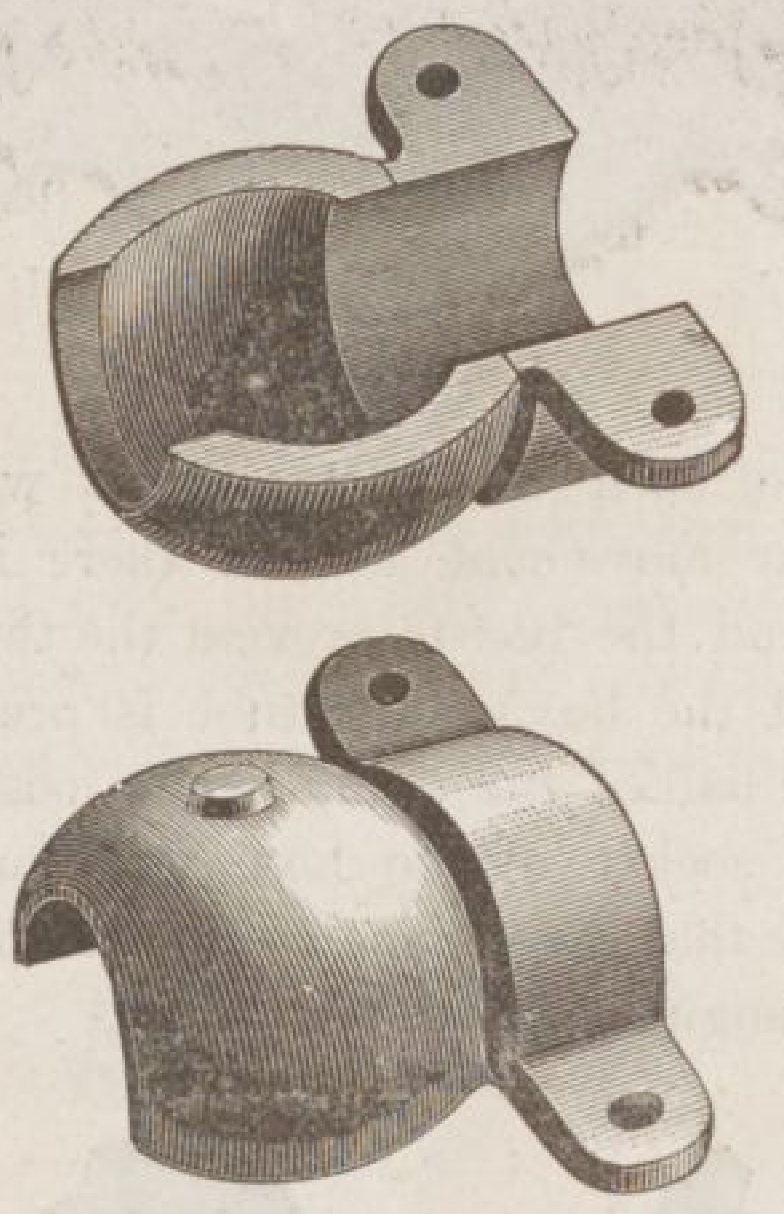


Fig. 3.

Fig. 2 shows the top and bottom halves of a "Coupling Box," a 3-conductor system, and Fig. 3 a "Ball Clamp," whilst Fig. 4 shows the bottom half of the same coupling box with tubes and ball clamps in place and joints connected. The two parts of the ball clamp being bolted together on the tube are thus securely clamped to it, the hemispherical parts come together to make a sphere which fits the spherical socket in the nozzle of the box; the two together thus form a ball and socket joint, allowing free angular movement of the tube in any direction, but preventing longitudinal movement of the box on the tube. The angular movement allowed by the ball and socket is limited to any amount in any direction, by providing a rib inside the box (either separate as in Fig. 11, or forming the inside opening of the ball-socket of the box, as in Fig. 2) of such a form, that when the extreme amount of angular movement to be allowed in any one direction is obtained, the tube projecting into the box through the ball clamp comes in contact with this rib, thus stopping any further movement in this direction.

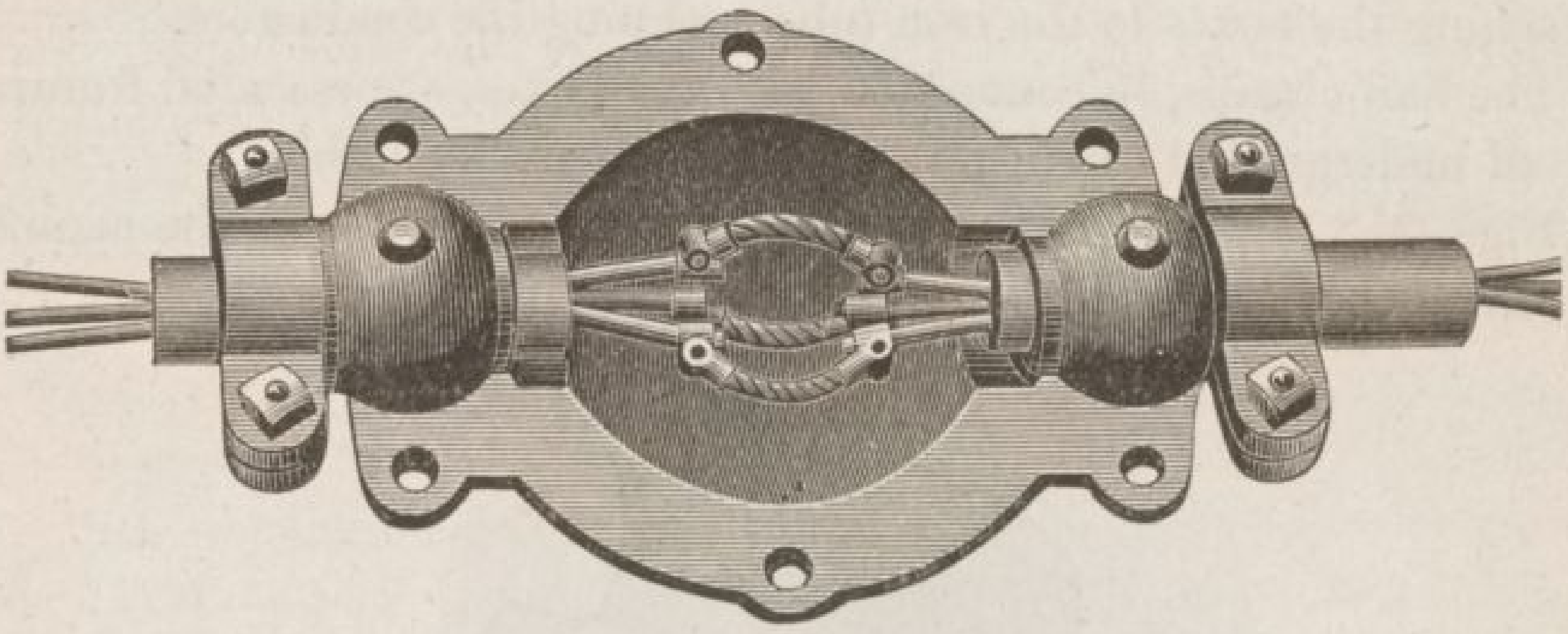


Fig. 4.

The box is made of such size and form, that when the tubes have the extreme angular movement allowed there is still ample space between the joint and the box to prevent the two coming in contact. Rotary movement of the box on the tube is prevented by means of the small lug on the ball of the clamp which loosely fits sidewise, the slot shown in the socket of the box, the slot being sufficiently elongated lengthwise that the lug may have free play in that direction within the limit of angular deivation allowed.

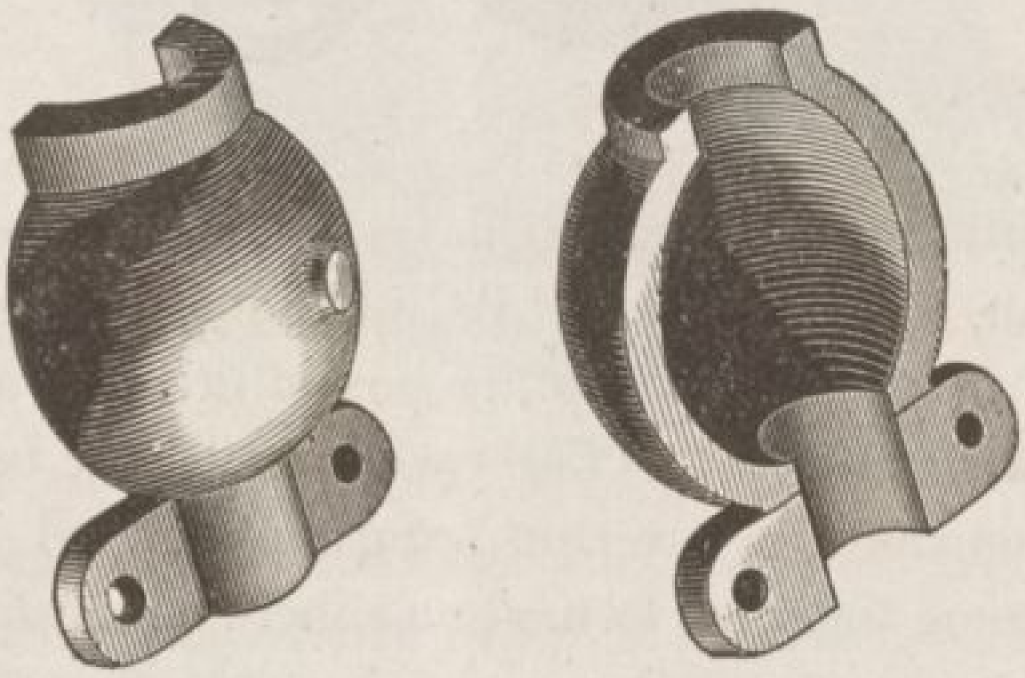


Fig. 5.

The limiting rib inside the box is made to give the angular movement allowed, when the largest size of iron tube that will go into the box is used, but any smaller iron tube may be used in this box (as, for example, in reducing the size of the conductor at this point) by means of a ball clamp, of the form shown in Fig. 5, with a ball to fit the box, but with a smaller semi-cylindrical groove in each half to fit the smaller iron tube; this clamp has in addition, as shown, a semi-cylindrical ring concentric with the groove cast on the ball of each half; the two, when the two halves are clamped together on the iron pipe, forming a cylinder projecting into the box, of the same outside diameter as the largest iron tube that will go in the box: this projection on the clamp striking against the limiting rib inside the box, limits the angular movement of the smaller iron tube to the same amount as when the largest size of iron tube that will go in the box is used. Therefore the ball clamp and box, as described, whilst making the iron envelope of the conductors mechanically continuous, and preventing rotary movement of the boxes on the tube; allow an angular deviation (in this case 1 in 10) in every direction, at each end of every box, which gives a degree of flexibility to the whole line (in this instance 11½ degrees at each joint) and at the same time renders it impossible that the joint should touch the box, with the extreme amount of angular deviation allowed. The ball clamp, modified as shown in Fig. 5, also permits the use in any box of any tube smaller than the largest that will go in the box, whilst preserving the same limit of angular movement.

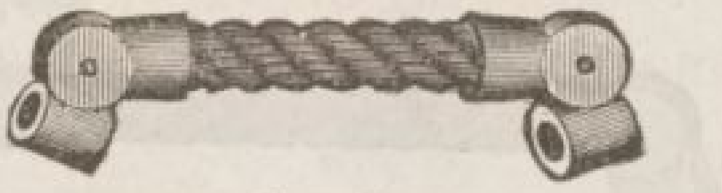


FIG. 6.

The flexibility of the whole line thus obtained is necessary for rapid and cheap laying in streets, where, from the number of gas, water and other pipes, sewer-manholes, etc., it is impossible to run tubes in a straight line for any distance.

The joints for 3-conductor tubes consist of pieces of copper wire rope, having cast or brazed on their ends suitably shaped composition sockets, in which are drilled holes to fit the size of copper conductor for which they are intended, and to which they are soldered in laying the line. The joints necessary to obtain the results illustrated by the exhibit are: "Coupling Joints," for connecting two tubes in a straight line (Fig. 6 shows the form of one piece, three such pieces being used for a complete joint); "90° Elbow Joints," for bending 90° to right or left, and "45° Elbow Joints," for bending 45° to right or left. Fig. 7 shows three forms of pieces, different combinations of which

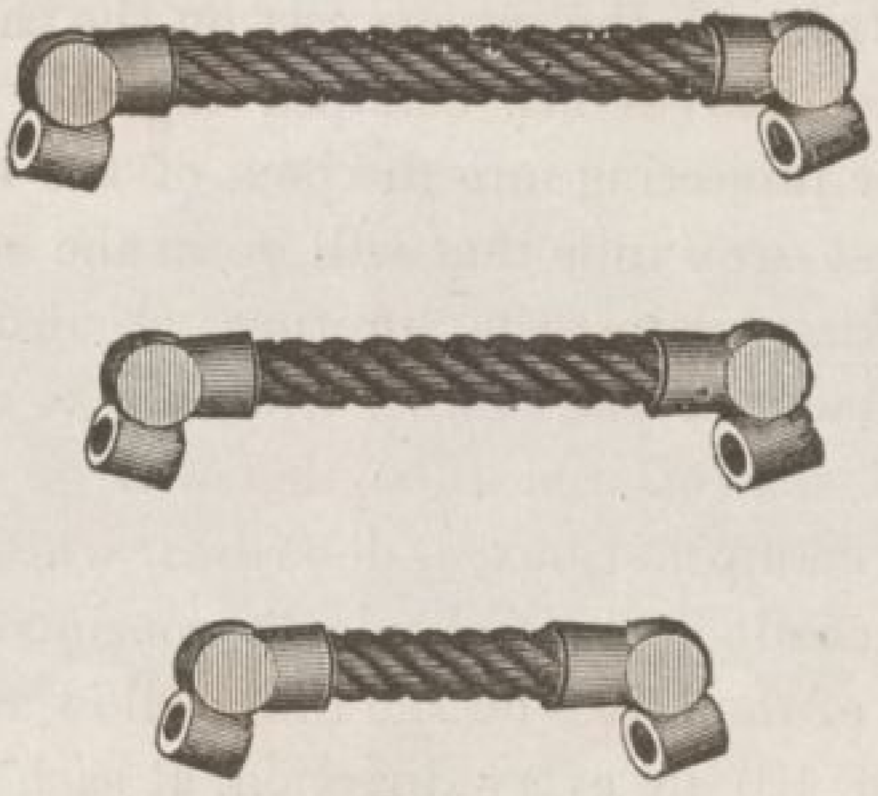


FIG. 7.

will make all kinds of elbow joints. "Branch Joints," by which, to any coupling joint in a line of any sized electric tube, may be attached a branch to one side, or one to each side, of any sizes not larger than the main line. Branches of sizes larger than the main line, being of rare occurrence, are not allowed for in the standard patterns for branches enumerated below, but, when required, may be made by a slight modification of the latter. Fig. 8 shows three forms of pieces, different combinations of which will make, to either or both sides of any coupling joint, branches of all sizes ordinarily required; a few of the largest sized branches require special patterns of modified forms, which are enuumerated below. The form of socket of the coupling joint shown in Fig. 6 gives the copper wire rope of the joint a bowed form when the joint is in place, to allow for the expansion of the conductors in each electric tube. The form of the joint when in place is seen in

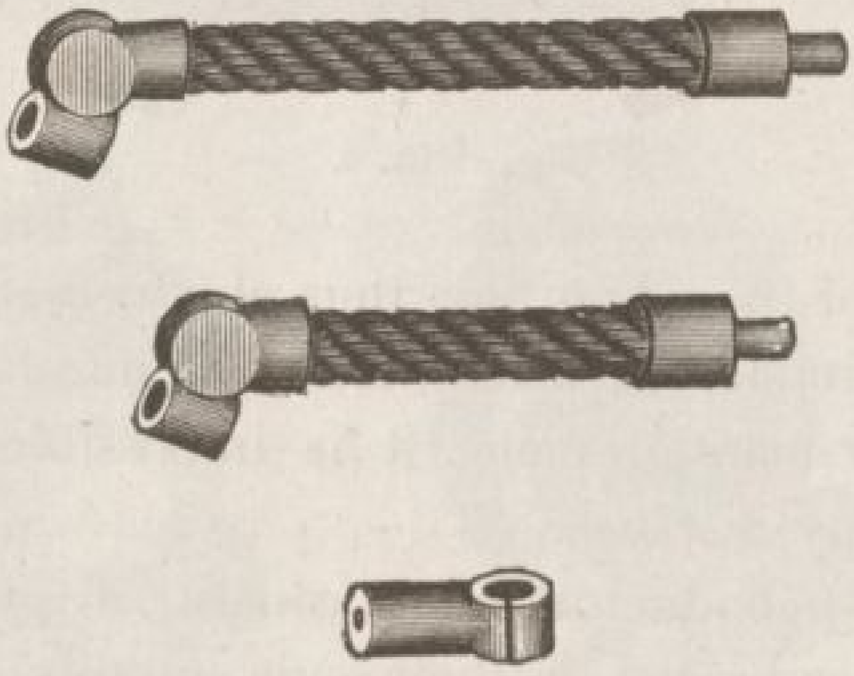


FIG. 8.

Fig. 2. Fig. 6 shows that, in addition to the hole which fits the conductor, each coupling joint socket has another hole drilled in it; the male sockets on the ends of the branch joint pieces (see Fig. 8) fit these holes and are soldered in them in attaching a branch joint; the female sockets on the other ends of the branch joint pieces are drilled to fit the conductors of the electric tube used for the branch lines. Fig. 9 shows a coupling joint, with a branch joint attached, in the bottom half of the box used for covering this kind of joint.

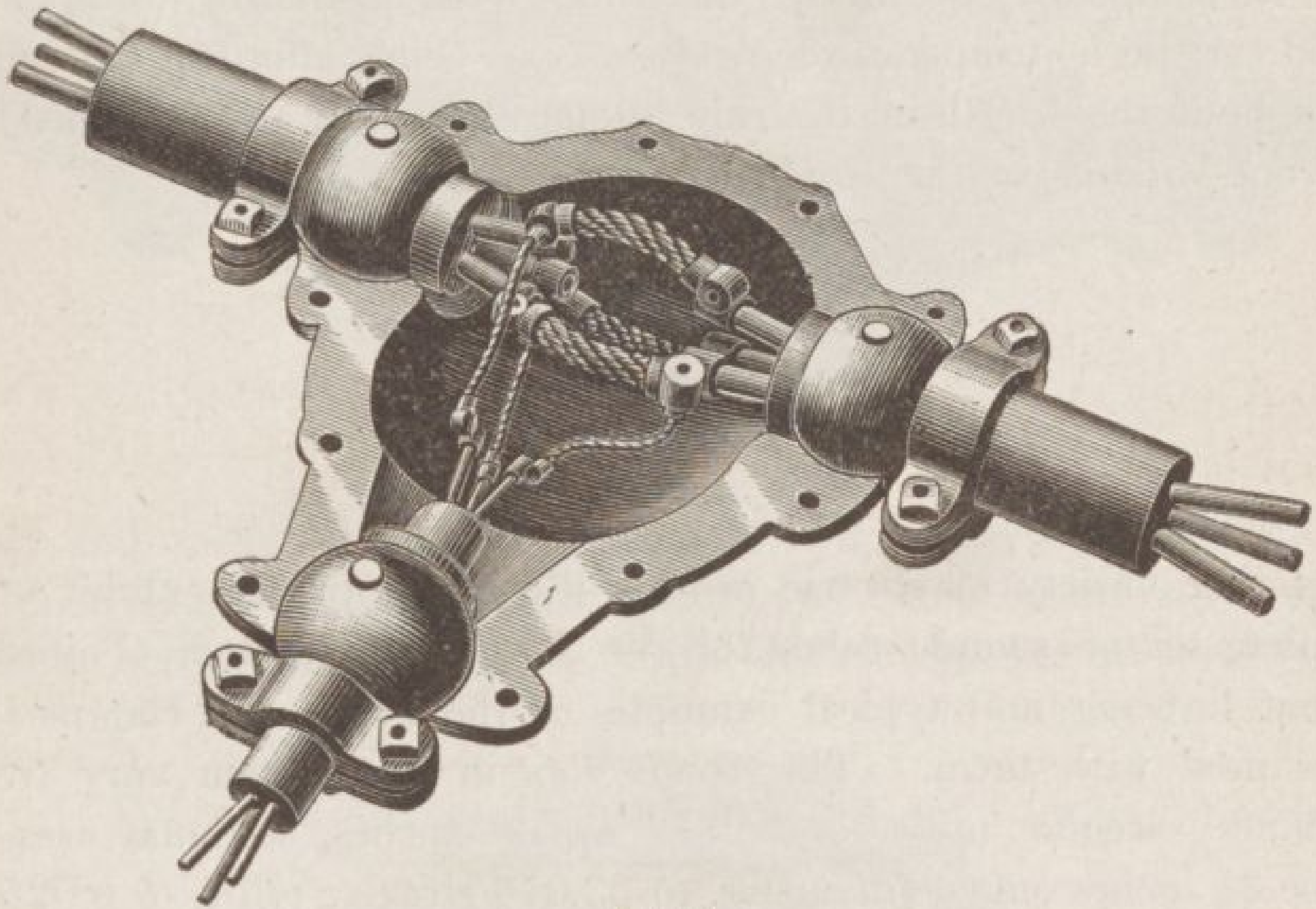


FIG. 9.

The 3-conductor system, so far as it is exhibited, has 21 different sizes of electric tubes, having conductors varying from 500,000 to 27,000 circular miles sectional area. The enclosing iron tubes are of 5 different sizes, varying from $2\frac{3}{8}$ inches to $1\frac{1}{16}$ inches outside diameter. All connections are made with 10 patterns of boxes, 8 patterns of ball clamps, and patterns of 43 pieces for all joints; of the latter, 6 patterns are required for coupling joints for all sizes, 3 of these patterns are also used for elbow joints, which require 15 patterns in addition, making 21 patterns for all varieties of all sizes of coupling and elbow joints. The remaining 22 patterns are for branch joints, and 12 of these will make any combination ordinarily required, the other 10 being for use in cases which rarely occur.

Electric tubes are exhibited cut away to show the internal construction, which consists in wrapping each copper conductor with a layer of insulating tape, and winding each taped conductor spirally with rope impregnated with insulation; the pitch of this winding is large compared with the diameters of the rope used, so that the windings of the several conductors fit between each other when the conductors are placed together; as many conductors as are to go in one tube, being so placed together, they are bound together by a final spiral winding of rope around them all, and the bundle of conductors thus formed being introduced into an iron tube, the process of manufacture is completed by filling the tube with insulating compound liquid, at high temperature, ready access being afforded the latter throughout the length of the tube, along the spiral paths formed by the rope-winding of the conductors.

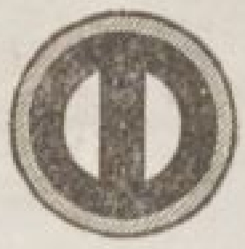


FIG. 10.

Another variety of electric tube is illustrated by an exhibit of a complete set of sample tubes for the 2-conductor system of incandescent lighting, and typical examples of the boxes, ball clamps and joints used with them. The conductors in this system vary from 1,639,890 circular mills, or 1·2879 square inches, sectional area in a tube $3\frac{1}{2}$ inches outside diameter, to 33,015 circular mills, or 0·02593 square inches sectional area in a tube $1\frac{1}{16}$ inches outside diameter, and, there being only two in a tube, economy of space in the latter is secured by making the conductors in the form of segments of circles, as seen in Fig. 10, which shows a cross section of one of these tubes. The joints for these tubes are of cast copper, the allowance at coupling joints for expansion of the conductors being given by making the joints with a U-shaped bend, projecting at right angles to the line of the tube, the section of the joint in the U being flattened to a parallelogram, long in comparison with its width, as is seen in Fig. 11, which shows a coupling joint for this system of tubes, with bottom half of coupling box. Holes are bored in all joints of the same form as the conductors for which they are intended, and to which they are soldered in laying. Boxes are exhibited with short tubes entering them, and joints connecting the latter, showing the forms assumed by different sizes and varieties of coupling elbow and branch, joints and boxes. Fig. 12 shows one variety of one size of 90° elbow joint, with bottom half of elbow box.

In both the 3 and 2 conductor systems, boxes and joints are shown for use in in-door lines of these tubes. The flexibility of the line which is required for underground work, and which is given by the ball and socket connection of clamps and boxes, is not necessary in in-door lines; the boxes may therefore be smaller on this account, and also on account of the absence of the ball clamps, the mechanical continuity of the iron envelop of the conductors being secured in small space by means of a ring which is screwed on the threaded end of the iron pipe and fits in a groove cast in the neck of the box (which neck fits the iron tube); this box is made in halves, which are bolted together over the joint, the end of the tube, and the ring screwed on the latter.

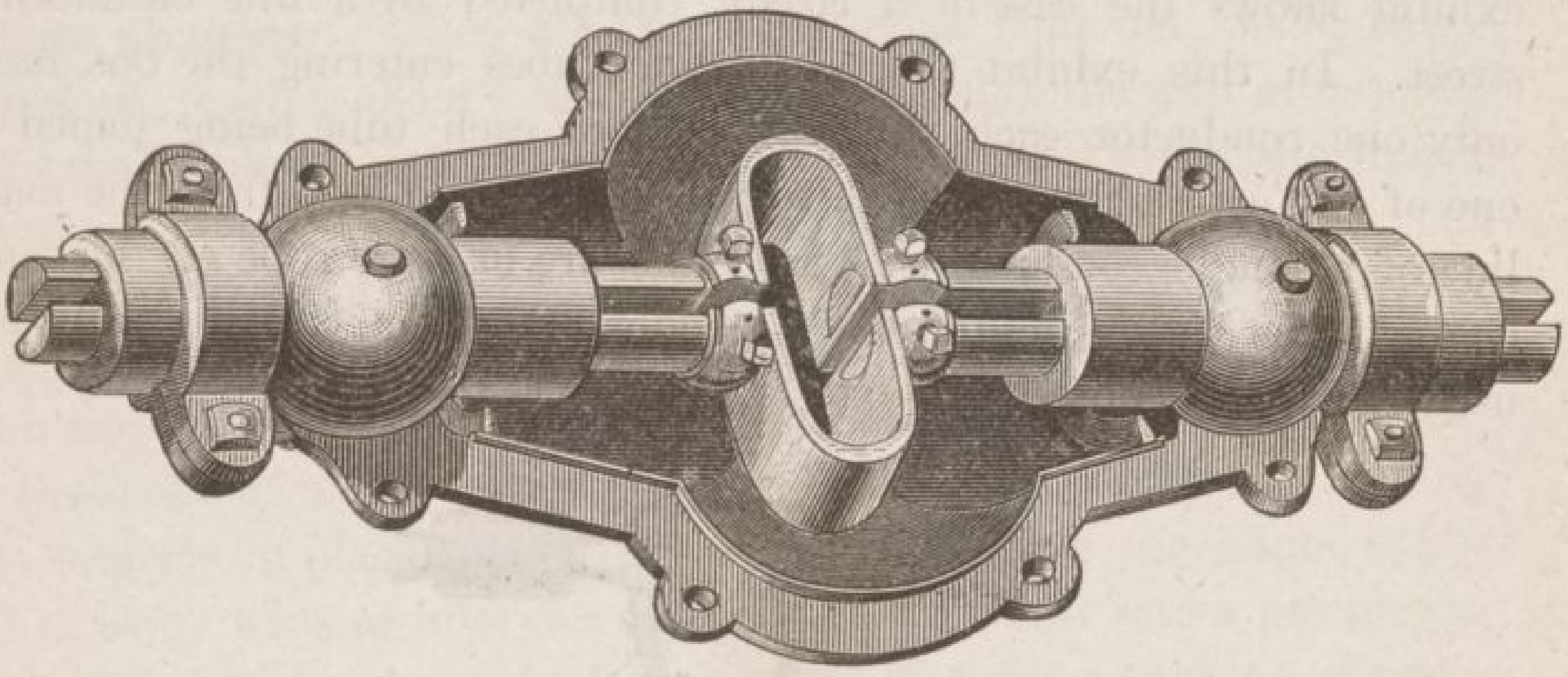


Fig. 11.

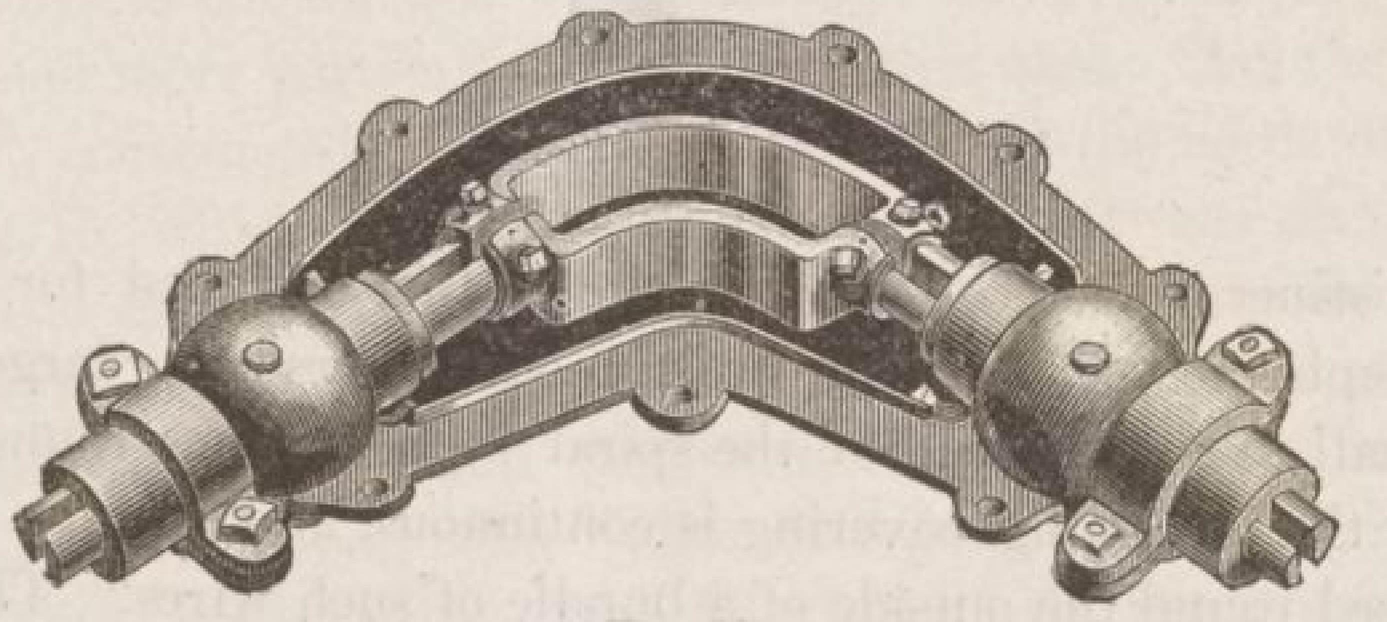


Fig. 12.

Underground arc light circuits were illustrated by two exhibits showing the character of the tubes and joints and the method of taking loops to lamps. One showed tubes with two round conductors for a complete circuit in one tube.

Fig. 13 shows this exhibit, and the method of making the joint so that, the branch tube being led off to a lamp or lamps, the two conductors of the branch form a loop of the main line. The second exhibit shows the case of a circuit completed by a line on another street. In this exhibit the main line tubes entering the box have only one conductor each, the conductor of each tube being joined to one of two conductors of the third tube, forming a loop from the main line of a single conductor. The joints are of wire rope of the same character as the joints for the 3-conductor system. Ball clamps are used to connect tubes with boxes.

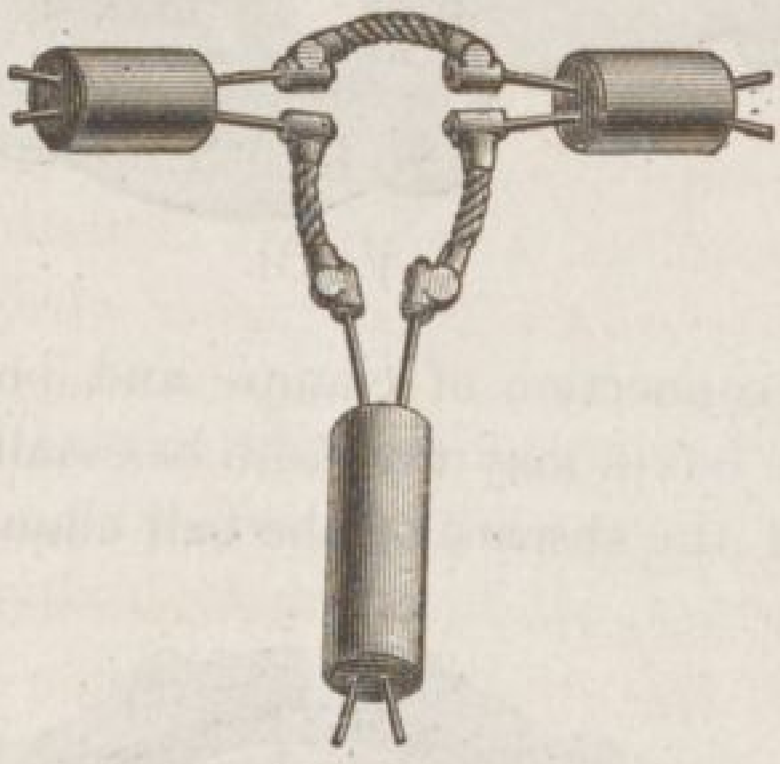


FIG. 13.

A distinct variety of electric tube is that designed for telegraphic and telephonic use. In this case, the conductors being large in number and small in size, instead of the spiral rope winding round each conductor, the insulating covering is continuous, and a rope winding is only used round the outside of a bundle of such wires. The wires are laid together regularly, on the basis of a hexagonal cross section for the bundle, and at each end are threaded through wooden screens which have holes drilled in them, in the same relative positions as the wires occupy in the tube. At one end of each tube, before being threaded through the screens, the wires are woven together so as to change the relative positions of the wires. This operation of weaving is simple and systematic, and the same for all tubes with the same number of wires, and is arranged on such a basis, that in conjunction with a systematic rotation of consecutive tubes, alternately to right and left, in the process of laying, it produces, in a series of long period, methodical changes in the relative positions of the wires in consecutive tubes, for the purpose of neutralizing the effects of induction. In making the joints of these tubes, wires threaded through corresponding holes in the screens are bent outwards and placed together in the same notch of a series of notched wooden slats, one for each layer of wires in the joint, which are built up one above the other, as the process of making the joint proceeds. When all the wires are so bent out, the ends are clipped off, leaving about 1 inch projecting through the wall of notched slats; the insulation is then slipped off the ends and each pair joined by a small sleeve, which is soldered to them to make the joint. In general, the joints of half the wires are made on one side and half on the other side of the box. Grooves are provided in the boxes into which they fit the wooden screens through which the wires are threaded, and the series of wooden slats built up in making the joint, holding these securely in place. By this method of making the joints, every joint of every wire, at intervals of 20 feet, is brought into a position in which it is readily accessible for purposes of testing, making connections, etc., without interfering with any other wire, so that at any such joint, loops or single service wires may be attached to any or all of the wires in the line. A line of this character, containing 37 wires was exhibited, with several consecutive boxes and joints to show the system of weaving wires in conjunction with alternate rotation of tubes. Such a line is adapted more particularly to telegraphic uses. Another box was exhibited, constructed with especial reference to the needs of telephone service, for which, in addition to trunk lines between stations, a number of wires are required for services in each block, and only run from the station to that block, thus giving a line between two stations a size decreasing gradually from each station to some point between them. The box exhibited, which showed a joint in a line of 217 wires, had a low turret rising from its upper half, the top of this turret was closed by a loose outside cover and an inside cover bolted down, and making a tight joint with the box by means of a rubber gasket; the whole being made water-tight by filling the space between the two covers, with the insulating compound. In every such box, along the face of a block, all those wires which are intended for use as services in that block, are bent upwards instead of outwards, in making the joint so that the joints of all such wires project upwards into the turret and are held in position by a wooden frame shown, whilst the the joints of all other wires are made out to the sides at a lower level;

this arrangement allows the box to be filled with insulating compound, covering all the wires and all joints, except the joints of those wires intended for use in that block, which latter joints project up above the surface of the compound, and on removing the cover of the turret are all immediately acccessible at every box along the block, for attachment of services, to any or all of them. Tapped holes are provided around the turret on the level of the joints of service wires, into which service tubes may be screwed, if electric tubes are used, or brass nipples to which are soldered the lead covering, if lead covered wires are used for service connections.

This company also exhibits specimens of lead covered wires of small sizes, and a specimen of flexible heavy conductor for indoor use, with large currents consisting of copper wire rope, taped, wound and lead covered. They also exhibit specimens of insulating tape, in rolls of 125 feet, continuous length, varying in width from 6 inches to ¼ inch, and jars of the insulating compound used in the tubes and boxes.

Comments by the Examiners Undersigned.

This system may be summed up as belonging to division "A a" of the Section's arrangement, or that in which the electrodes are permanently sealed. When any portion of an electrode is destroyed a new one is not introduced, but a new length of pipe is substituted, containing the necessary number of wires and attached at its extremities. The details are very fully given, and with the cuts render it unnecessary to repeat them. With a large stock of lengths and boxes and with trained workmen, the work of laying the conductors only a few inchee below the surface of the streets would be comparatively rapid. While in the tentative stage of underground service this does not present the same amount of convenience as a system where wires may be introduced and removed at will; and presents the objection common to all "section" systems that the conducting capacity of the whole line is that of the most imperfect of splices made every twenty feet, yet it answers the demands upon it much better than those systems which require expensive and tedious derangements of the street in order to accomplish repairs. The seat of an accident to one of the wires of this system is located from the central office, on and between known streets. The manhole is opened and the safety catches first of all examined. The managers assert that the place of the break can then be so accurately located that the length containing it (usually about twenty feet) may be at once removed and replaced by another.

The telephone and telegraph, and the light and power wires are not enclosed in the same tube. The insulating material with which the boxes are filled is still flexible at 32° F., but brittle at 0° F.

The method of laying and tapping for private dwellings would seem to afford complete protection against lightning. The three-wire system which has been grafted upon the Edison conduit system effects a saving of 62 per cent. on that required for the two conductor system, in the copper necessary for conductors.

The light and power system are not adapted for use by various companies, independently, though the telephone and telegraph conduits might be so applied.

The details of this system have been so perfectly elaborated, that in view of the fact that no complete description of it has been heretofore made public, the undersigned deemed the above full report desirable.

THE NATIONAL UNDERGROUND ELECTRIC COMPANY OF NEW JERSEY.

("C." of the Section's Classification.)

This conduit consists of a number of metal tubes imbedded in a kind of insulating pitch, formed in a suitable trough. At the corner of each street there is a water-tight man-hole for hauling in or out wires as required. Provision is also made for tapping wires for house-to-house supply. This forms the subject of a separate patent. It is proposed to place telephone, telegraph and electric light wires in different tubes, so that they shall not interfere with one another. The metallic lining of the ducts, it is claimed, will pass off readily any induced currents which may be generated. The moisture or damp can be kept out by forcing dry air through one or more of the tubes or conduits from a fixed plane along the line.

The Company state that the cost of the conduit per mile will be $8,300. A mile of conduit has been laid under Market street, Philadelphia. The committee were unable to examine its condition, as it contains no wires at present.

(No electrotypes were furnished by the company to accompany this report.)

HENDLEY'S CONDUIT FOR UNDERGROUND LINES.

"A. b." of the Section's Classification.)

Description of Inventor, edited by the Examiners undersigned.

This system consists of a semi-cylindrical trough or conduit for the reception of the conductors, with a suitable cover of any desired configuration, angular shaped being preferred, as by its removal, when necessary, the wires and their supports are more thoroughly exposed. Below the trough and integral therewith, is a drain-pipe of suitable diameter, for carrying off all moisture that may find its way into the conduit by condensation, exudation or leakage. A narrow slot extending throughout the length of the trough opens therefrom into the drain-pipe, the curved sides of the former rendering it almost impossible for any heavy particles of moisture to remain therein, this slot serves also to sustain the bolts which pass through the shoe to which the standard of the wire supports are secured, thus rendering it easy to place the supports at such intervals as may be desired, along the conduit. This structure, with the supporting arms is really "a telegraph pole underground." Modifications of these slotted arms have been suggested, which it is thought would, in practice, make this feature thoroughly effective.

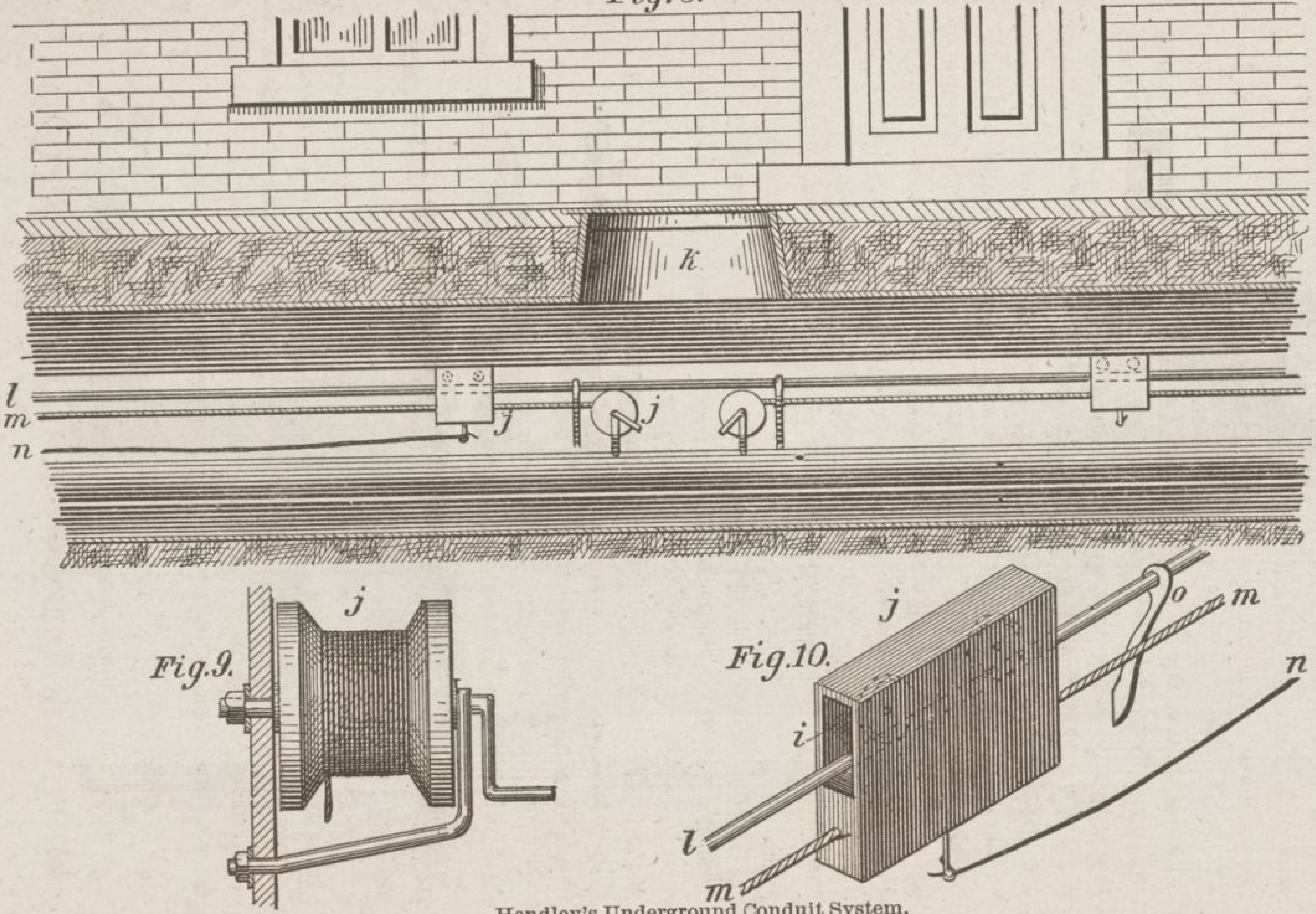
Testing chambers are placed at such suitable points along the line as may be necessary, and in these, provision is made to test, tighten and otherwise manipulate the wires. A full description of this feature of the system cannot be fully set forth herein. At one side of the conduit brackets are secured, and from these rods extend, over which travelers having suitable pulleys in their interior which move on the rods, pass and carry the wires from man-hole to man-hole, cords are attached to each side of a traveler, and pass thence to reels secured near the surface of the earth, these man-holes can be placed at frequent intervals along the line, by securing wires to a suitable clamp at the bottom of the traveler, and they may be run in at any point simply by reeling in the cord.

Pipes for inducing currents of air are led into chimney stacks the heat of which is made available for that purpose, or they may pass into the open upper air, and currents of hot or cold dry air may be forced into the conduit by means of fan blowers, both devices may be used, though either separately would be effective for carrying off all

Fig. 8.

Fig. 9.

Fig. 10.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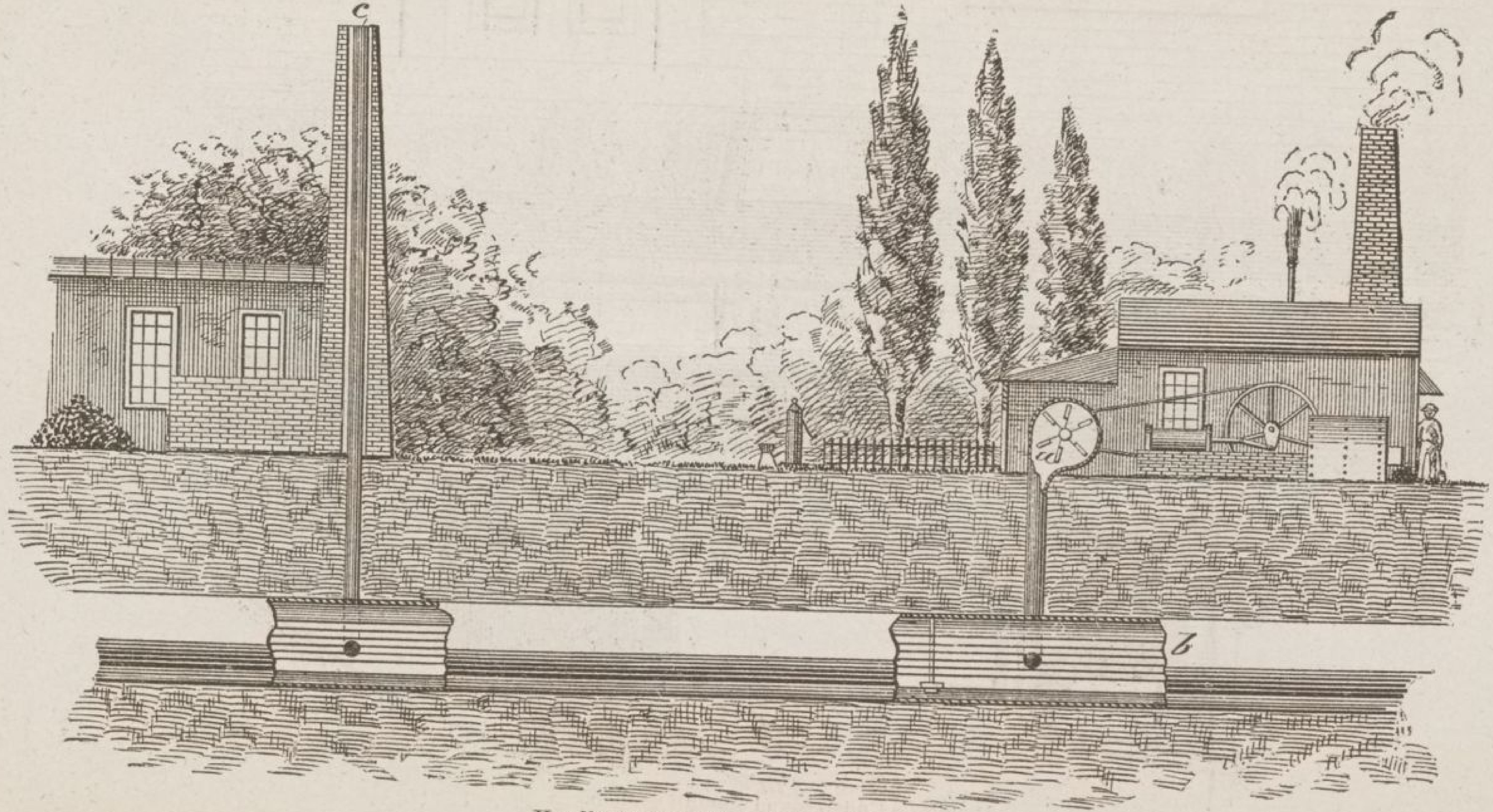
Hendley's Underground Conduit System.



Hendley's Underground Conduit System.

the lighter particles of moisture, and thereby keeping the conduit thoroughly dry and at a uniform temperature all the year round, and thus rendering, it is thought, a thorough insulation of the conductors unnecessary. Provision may be made by this system for a future increase in the number of conductors to be employed, without having to tear up the streets, so that when once the system is built it remains a permanent and available plant, adapted not only to present but to future use.

Comments by Examiners.

This conduit consists of a semi-cylindrical trough of iron, terra cotta, or preferably, of glass, fitted with an angular-shaped cover. At the bottom of the conduit there is a pipe connected to it by a slot, for the purposes of drainage, and for fixing a standard with recessed and insulated arms for carrying the wires.

Man-holes are provided at suitable points, and also small pipes for house to house supply.

Provision is made for either ventilating the conduit by induced currents of air, or of forcing hot or cold air through it in order to expel all moisture. No provision is made for induction in telephone wires. The standards carrying the wires are secured to the conduit by one bolt each, and it would seem difficult, without continual inspection, to keep them in position.

Note.—Neither the inventor nor any one representing him could be found to answer the questions of members of the Section as to his method of running in wires, etc., and no estimate of cost was furnished.

MAGNER'S UNDERGROUND CONDUIT.

Patented June 10, 1884.

(*"A. b." of the Section's Classification.*)

This system consists of a conduit constructed of cast iron, terra cotta, etc., having a longitudinal slot *A′* at its top, for the introduction of wires or cables. This slot is beveled and made tight by bolts and clamps bearing on the inside of the conduit (See Fig. 5.) The joint is further secured by suitable packing.

The wires or cables are supported on insulated rollers, which revolve freely on a series of horizontal shafts, suitably supported and arranged one over the other. These rollers may be formed in one piece, or may consist of a number of independent rollers separated by washers. The distance apart of the rollers both horizontally and vertically, is such as to prevent contact between the wires or cables, when strained up.

The Inventor claims that his system provides a conduit applicable to all descriptions of wire or cable; which is easy of access for the insertion or removal of any wire or cable, and in which the wires are kept taut.

The Inventor did not submit any plan for manholes, or any arrangement for providing house-to-house supply, nor does he claim any method of obviating the efforts of induction. He proposes to lay down well insulated wires, as the conduit would be necessarily more or less damp.

After the conduit has been laid and filled with wire, any alteration to the system would require that the street should be opened from end to end.

FIG. 2.

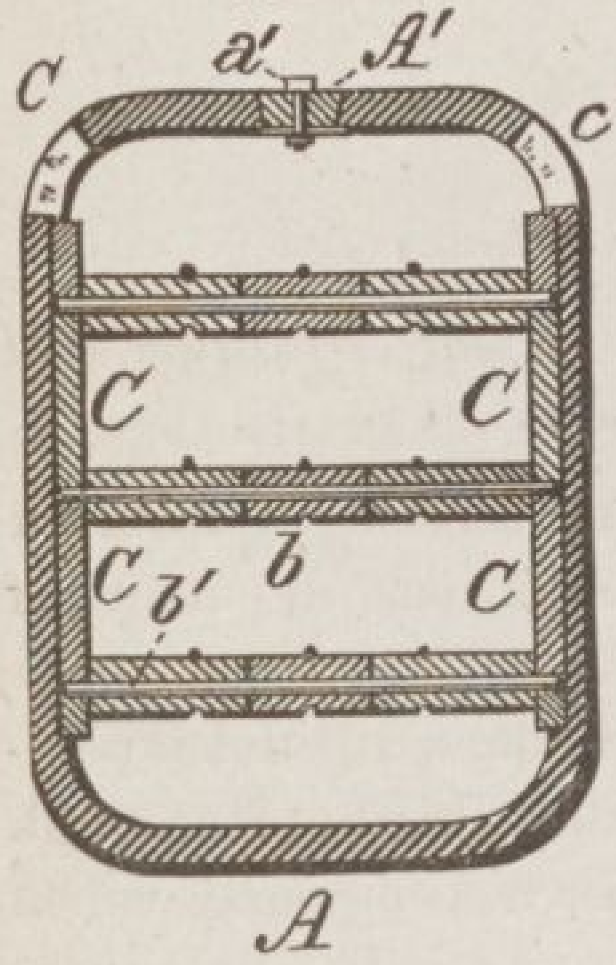

c
a'
A'
c'
C
C
C
b
C
b'
A

FIG. 1.

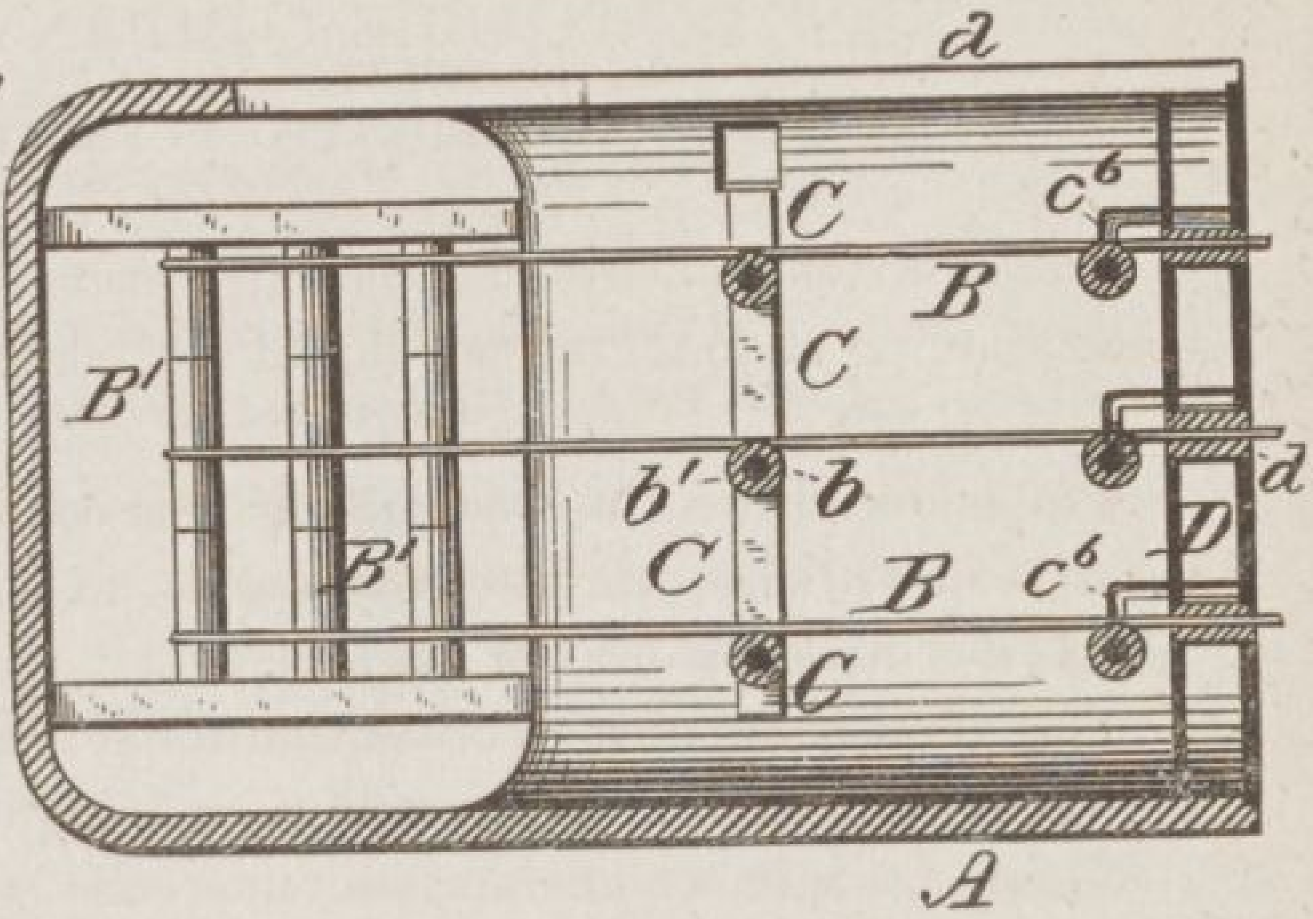

a
C
c^6
B
B'
C
b'
b
a
B'
C
B
c^6
D
C
A

FIG. 5.

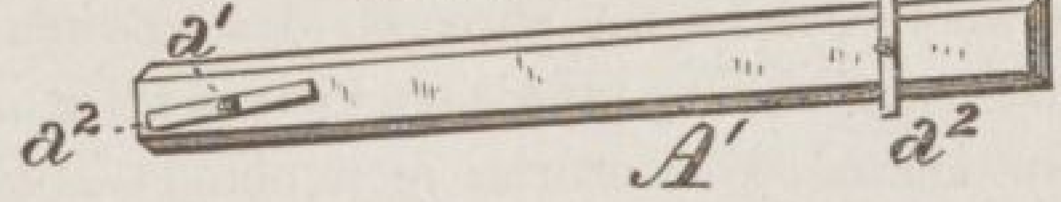


FIG. 6.

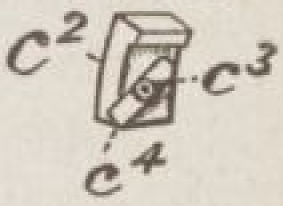


FIG. 4.

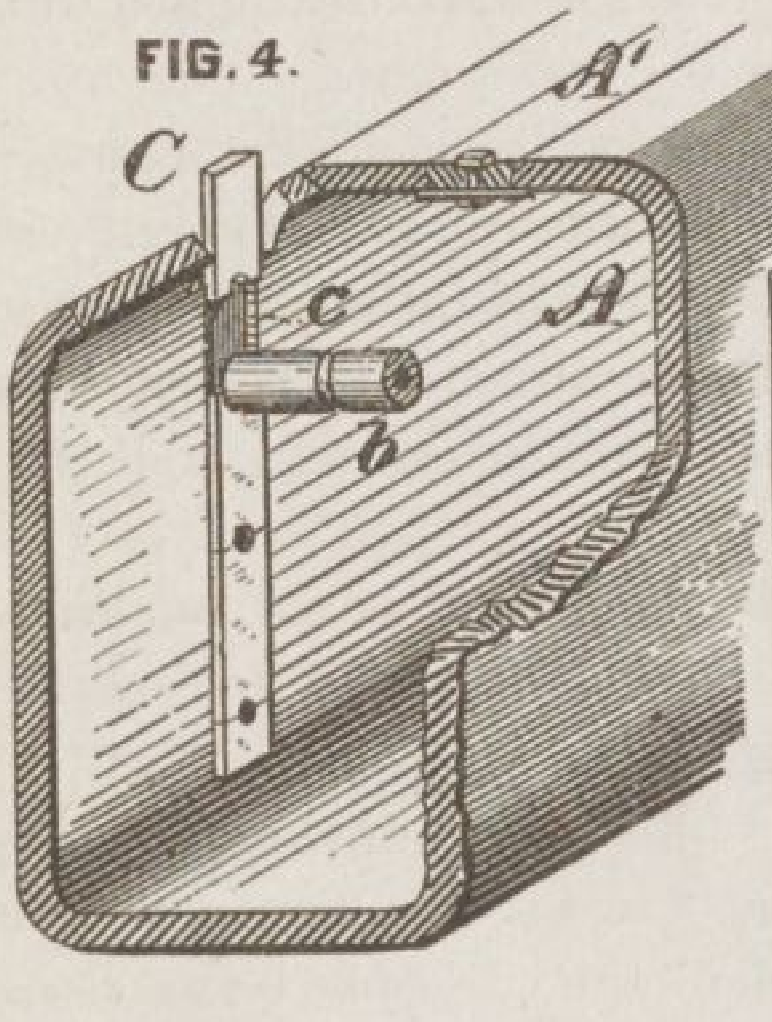


FIG. 3.

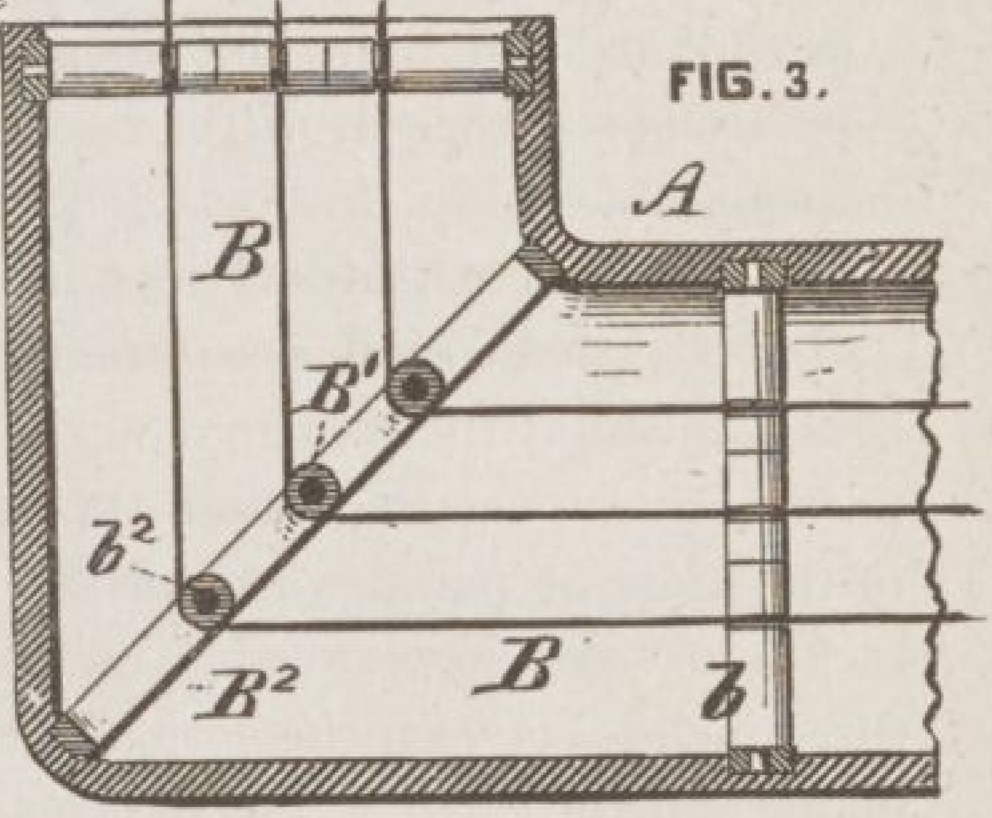
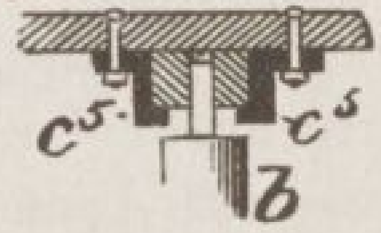


FIG. 7.



PHILADELPHIA AND SEABOARD TELEGRAPH AND CABLE COMPANY.

(CALLED ALSO PENNOCK'S.)

(*" A. a." of the Section's Classification.*)

Description of Pennock's Underground Conduit for Telegraph and Telephone Wires.

The material used in constructing this conduit, consists of hemlock wood, copper wire, various compounds and insulations, the nature of which the inventor did not disclose.

The wood is exposed to a solution for several hours, at the temperature of boiling water. The composition being easily distributed through the mass of soft wood, incrusts the cells with a compound which makes the wood absolutely moisture and decay proof. The carpenters now take the wood (which has become dry and hard) and make a hollow box—the core of the conduit—which is filled in with insulated telephone wires, arranged according to a plan not disclosed. When the core is filled, insulating material is again poured upon the wires, filling in the interstices, making a dry solid mass. The top is now cemented on. The finished core now receives a second coating of the waterproof compound. (Fig. 1 shows the completed core.) Around this core are now built the receptacles for the insulated telegraph conductors (as shown in Fig. 2.) There are two inches of insulating impermeable compound between the telephone and telegraph circuits, 6 inches between all sides, ½ inch all around.

The finished core is now set in the outer shell of the conduit, which is also made of the prepared wood, 1 inch thick. A moistening compound is now run in around the core and the top covered with a plank of the same prepared wood, pressing into the compound, making two inches of solid impermeable matter between the core and the casing, three inches between the core and the earth, 5 inches between the telephone and the earth. The sections are all prepared at the factory before being taken on the ground. They are run into sleeves every 20 feet; 20 loops are run out on each side of the sleeve and covered with a water-proof cap, so that the wires are at all times accessible. The wires are connected through the sleeve with a patent, hard paper, double connector.

The electric light conduit is made in a similar manner, but the wires

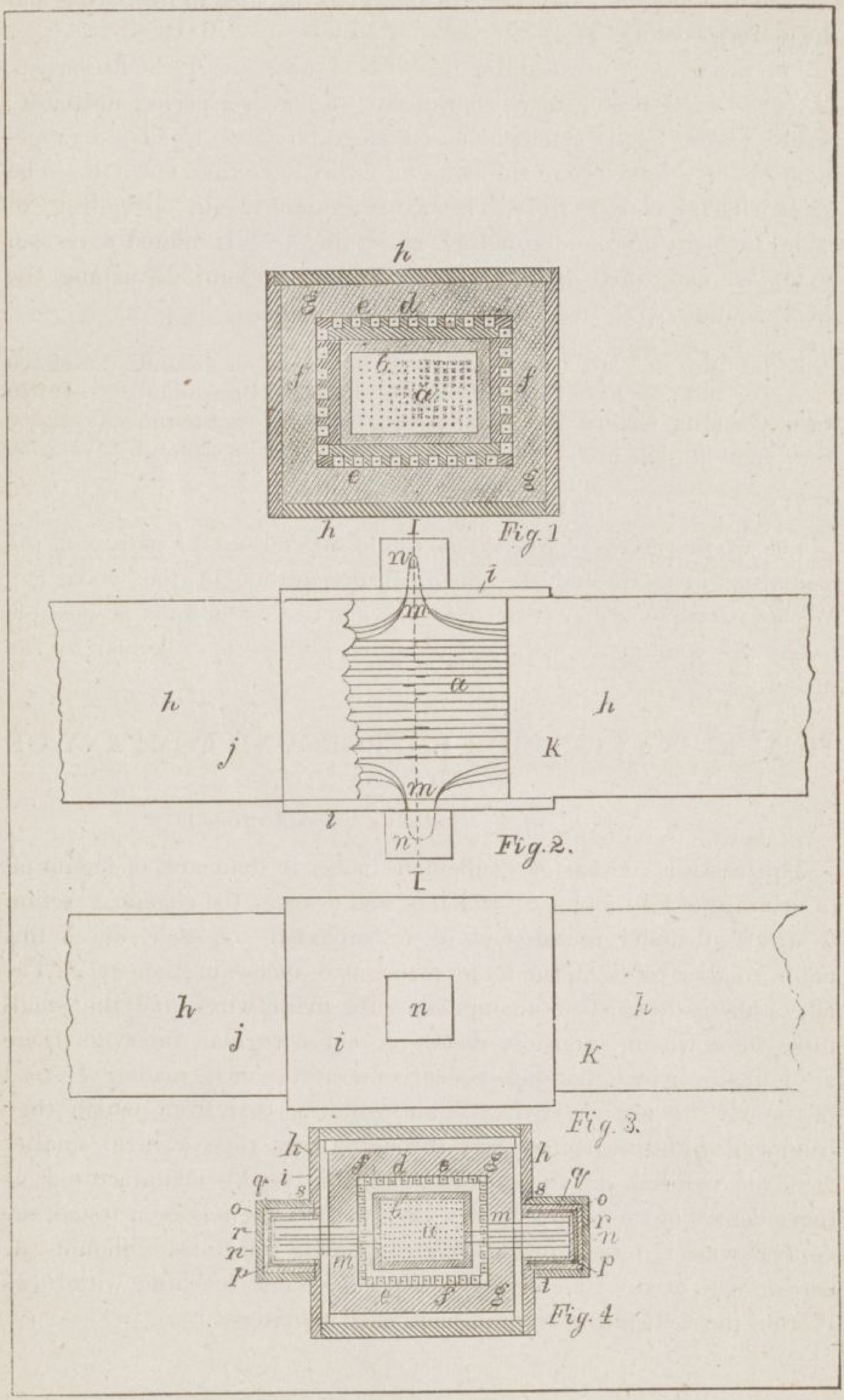

h
g
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Fig. 1
l
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Fig. 2.
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K
Fig. 3.
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e
g
b
a
m
Fig. 4

Pennock's Underground Conduit System.

are widely separated, and different materials are used in insulating and fire water-proofing.

The advantages claimed for this system are: (1.) It is fire-proof; (2.) It is water-proof, it will not decay; (3.) It is a perfect insulator; (4.) No leakage between telephone and telegraph wires; (5.) The arrangement of the conductors in the lanes to divert induction, etc.; (6.) The wires will not corrode; (7.) The wires cannot break, no pulling of cables through tubes, no abrading, no strain; (8.) Insulated wires can be tapped and conveyed into each dwelling without disturbing the main conduit; (9.) It is cheaper than a pole line.

Price per mile for 100 Telephone wires, delivered on ground........	$2,500
Price per mile for 1000 Telephone wires, delivered on ground........	$9,750
Price per mile for 100 Telegraph wires, delivered on ground........	$2,750
Price per mile for 1000 Telegraph wires, delivered on ground........	$12,750

Comments by the Examiners.

The whole success of this sytem would depend on the nature of the insulating material and the chemical preparation of the wood, etc. Without trial, over an extended period of time, it would not be possible to test this conduit for endurance and the other points claimed by the inventor.

THE UNION ELECTRIC UNDERGROUND COMPANY OF CHICAGO.

("*A. a.*" *of the Section's Classification.*)

This conduit consists of a tube ten inches in diameter, of kalamine (a mixture of lead and tin) which is said to resist the chemical action to which all underground conduits are subjected—on each side of this main, smaller tubes of the same metal, two inches in diameter. The large tube is designed to accommodate the main wires and the small tubes those which run short distances, and at regular intervals there are joints by which house-to-house connection can be made. Instead of the wires being covered with an insulating coat, from which they cannot be withdrawn, they run through a tiny pipe, a little smaller than the familiar maccaroni tube, and this pipe is manufactured independently of the copper wire. When this pipe has been tested, the copper wire is forced into it by an ingenious machine. Should the copper wire at any time need repairing the same machine withdraws it from the well-fitting covering and then replaces it.

The inventor claims that this tiny tube is the best insulator known. It is made of vulcanized rubber, three sixteenths of an inch being its thickness, and one-sixteenth of an inch being the diameter of the opening. The rubber is covered with a thick electric deposition of copper. The deposition surrounds the tube and is said to prevent induction by carrying the surplus electricity into the ground.

By the tube system each wire can be removed without the others, with which it is bunched, being disturbed in any way. The electric light wire which, on account of the great insulation, can be handled with perfect safety when the strongest current of electricity is running on it, costs less than $500 a mile, or half the usual cost, and takes up about half the space that an electric light wire usually occupies.

The inventor claims that by the use of his special insulation he can run all descriptions of wire in one tube.

The conduit can be laid for $8,000 a mile. The main tube will hold 1,700 wires, and the side tubes 50 each.

The insulation was found to be very brittle—and it would be difficult to bend it out of the manholes and tapping tubes without injury. The wires must be necessarily very expensive—not only to manufacture, but to force into their insulated tubes afterwards.

WOODWARD'S CURB CONDUIT.—SYSTEM B.

(*"A. b." of the Section's Classification.*)

Company's Description Edited by the Undersigned Examiners.

In the accompanying engraving, Fig. 1, is a perspective view of the combined curbstone and conduit, showing the wires in position; in the second figure the wires and cover are removed; Fig. 3 is a vertical section taken at a street corner; and Figs. 5 and 6 are plan views at street corners, the former being an inlet corner and the latter the usual rounded corner; Fig. 4 is a horizontal section illustrating the method of securing together the conduit sections in order to permit expansion and contraction. The hollow curb conduit sections, *A*, made of cast iron or other suitable material, are formed with vertical sides above the street pavement to form the curb, and those portions sunk in the ground are widened out at the bottom to guard against displacement and provide ample space. The cover, *J*, is about flush with the sidewalk. Between the cover and the top of the ledges is placed a water-tight packing. The wires are supported by a series of vertical racks, *E*, fixed at suitable intervals apart. The lower ends of the racks enter sockets in the bottom of the conduit, while their upper ends pass through holes in cross stays, *D*, the extremities of which rest in brackets on the sides. The ends of the conduit section are flanged and bolted together, packing being inserted between them.

When it is necessary to provide for longitudinal expansion and contraction of the several sections, they are made with overlapping ends, and are secured by bolts passing through slots in one of the flanges. Packing is placed between the joints. The wires are inserted from the open top of the conduit and rest in the teeth of the racks; after they are in position the cover is bolted down. When it is desired to conduct one or more wires into a building, small lateral pipes, *L*, are connected to the side of the conduit. With this construction the wires are always easily accessible and the tearing up of the pavement in order to reach particular points is obviated. The two-plan views show clearly the methods of rounding corners. When the conduit crosses the street where the curb ends, those wires which are above the line of the depressed part are directed downward (Fig. 3), and kept in place by means of transverse studs, *N*.

The advantages claimed for this system are: That it is easier and cheaper to place the wires in the curb than to tear up the streets and put them in an underground conduit.

That owing to the curb conduit widening and deeping from the level of the paved street it gives ample room for holding any number of wires.

That to introduce into a house any telegraph, telephone or electric light wires, by merely removing a few bricks from his pavement, the connection is made direct with the curb conduit, instead of excavating many feet of earth in the pavement and the street by the underground conduit.

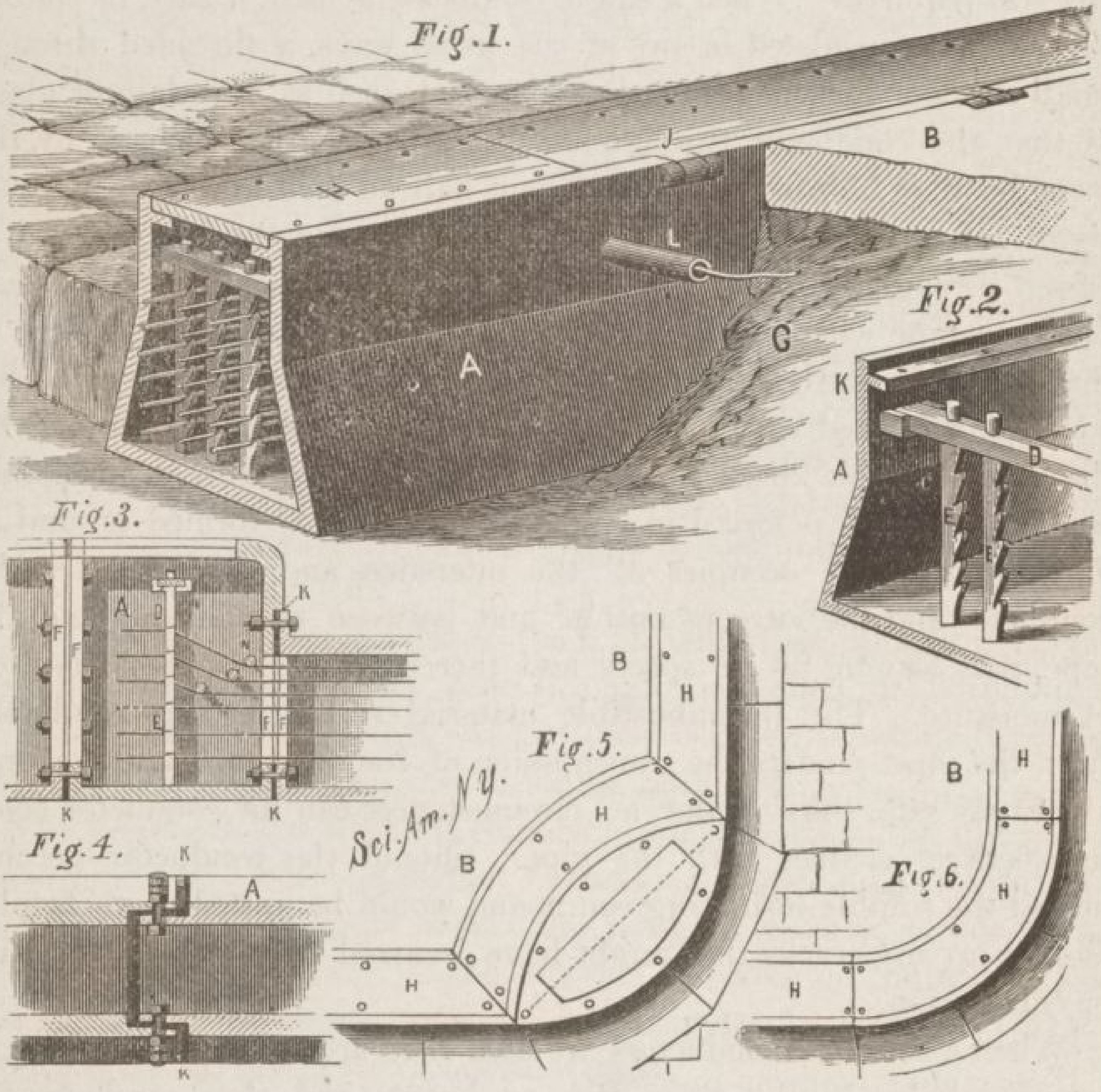
That it is always accessible.

If anything happens to a wire, or a new one is to be introduced, one can always get to it in the curb conduit, and during the snow and ice of winter when the authorities of cities will not allow the streets to be opened, the curb conduit is as accessible as in the warm months of summer.

Comments by the Examiners.

In this system no provision is made for keeping the conduit free from moisture, so that a first-class insulation is required for the wires or cables used. Further, no method is proposed for obviating the efforts of induction in telephone circuits.

To obtain the advantages claimed for it, a conduit must be run on both sides of the street in order to give house-to-house supply.



It would further appear that a long line of iron plate along the sidewalk would be dangerous to foot passengers in frosty weather, and would interfere with present arrangement of gas lamps and the existing sub-pavement and street cellars.

No estimate of cost was given. The system would necessarily be an expensive one.

THE DELANY CABLE

FOR ELECTRIC LIGHTS, TELEGRAPHS, TELEPHONES AND ALL ELECTRICAL CONDUCTORS.

Description of the Inventor Edited by the Examiners.

("C." of the Section's Classification.)

This cable may comprise any number of conductors desired, and of any size required. When a single conductor is used, a bare or cotton-covered wire, insulated in any of the usual ways, is threaded through small disks or buttons of vitreous material, such as porcelain or glass, so that the conductor throughout its entire length is covered by the incombustible buttons which are about half an inch in length and one-eighth of an inch in thickness. The conductor thus surrounded is passed through a compound of insulating material and through a lead press machine which encloses the whole in a lead covering or pipe, so that, when finished, the cable or conductor is first enclosed in a braided covering saturated with an insulating compound, then surrounded by the incombustible disks or buttons, again covered with an insulating compound which is forced in hot as the lead pipe is formed around it. The latter filling occupies all the interstices and space between the conductor and the vitreous buttons and between the buttons and the pipe, thus leaving no air spaces and thereby preventing condensation of moisture. The incombustible material separating the conductor from the pipe, renders the transmission of the most powerful currents absolutely safe, since under no circumstances can the conductor come in electrical contact with the pipe. Should the conductor become heated the soluble insulating compound would be united more firmly, closing up any cracks that might have occurred from low temperature or contraction.

When a series of conductors are used they are all threaded through separate holes in the same disk or button, and thus mechanically separated from each other and from the pipe in which they are enclosed.

This cable is practically indestructible, as its durability is only limited to that of the enclosing pipe, which may be of lead or iron. When lead is used the cable may be constructed in lengths of one-quarter or half a mile without splicing, and coiled on a reel, the vitreous disks admitting of flexing to any extent necessary.

The conductors cannot become crossed, nor can they be grounded so long as the enclosing pipe remains intact. As the lead pipe is formed around the cable in a molten state, there is no seam, weld or joint throughout the entire length in each section.

All danger from fire in buildings is obviated. Rats cannot destroy the insulation and the cable may be laid in chimneys, ventilation or heating flues, or placed in the walls like gas or water pipes, with perfect security against interruption or damage, or the necessity for tearing out the walls for repairs of any kind.

Three tests of this cable were made at the International Electrical Exhibition, for the purpose of ascertaining the effect of powerful currents on the insulation. These tests were made under the direction of Capt. de Wolski, Chairman of the Committee on Underground Conductors. The first consisted of placing a piece of cable about five feet in length so as to short-circuit the Hochhausen electro-plating dynamo-machine. Ths conductor, a single one, insulated as described in the beginning, was No. 4 Birmingham gauge copper wire. The dynamo-machine had an electro-motive force of two and one-half volts. A current of 600 amperes was passed through the cable for 20 minutes. The conductor was made red hot, but the insulation was uninjured, the melting of the filling-in compound being the only result of the experiment.

The second test was similar to the first, with this difference in the current—800 amperes were sent through the cable for 20 minutes. The wire became so hot that the vitreous disks surrounding it melted the lead covering, leaving the insulation uninjured.

The third test was with the conductor inclosed in an iron instead of lead covering. When sufficient current could not be passed through the conductor to cause any effect other than the melting of the filling compound and charring of the braided covering on the wire. The conductor was perfectly secure in its insulated separation from the pipe and consequently free from all danger.

This single conductor, insulated and inclosed as described, ready for use in the ground or elsewhere, can be furnished for 22 cents per foot. Six separate conductors of No. 16 copper wire, for telegraph or telephone use, and covered in a like manner, will cost the same amount.

The foregoing report is respectfully submitted by

F. D. de WOLSKI (*Chairman*),
PERSIFOR FRAZER.
LUTHER L. CHENEY.
Examiners of Section XVIII.

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1884m

1884-INTERNATIONAL ELECTRICAL EXHIBITION-1884

REPORT OF EXAMINERS
OF
SECTION XXI.

FIRE AND BURGLAR ALARMS AND ANNUNCIATORS.

"Merrihew Print" (J. Spencer Smith), 501 Chestnut St.

Philadelphia.

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884
OF THE
FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA,
FOR THE
PROMOTION OF THE MECHANIC ARTS

REPORT OF EXAMINERS

—OF—

SECTION XXI.

(SECTION IV., CLASSES III. AND IV. OF THE CATALOGUE.)

FIRE AND BURGLAR ALARMS AND ANNUNCIATORS.

[ISSUED BY AUTHORITY OF THE BOARD OF MANAGERS AND PUBLISHED IN THE JOURNAL OF THE FRANKLIN INSTITUTE, JANUARY, 1885.]

PHILADELPHIA:
THE FRANKLIN INSTITUTE,
1885.

~~TK6 .P546~~
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t.c. - June 1, 1909 - E.M.E.
S.S.B. Nov. 26/06

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INTERNATIONAL ELECTRICAL EXHIBITION, 1884.

FRANKLIN INSTITUTE, Philadelphia, Pa.

REPORT OF EXAMINERS.

SECTION XXI.—FIRE AND BURGLAR ALARMS AND ANNUNCIATORS.

To the Board of Managers, Franklin Institute:

GENTLEMEN:—I have the honor to transmit herewith the report of the Examiners of Section XXI, on Fire and Burglar Alarms and Annunciators.

Respectfully,
M. B. SNYDER,
Chairman Board of Examiners.

PHILADELPHIA, *December*, 1884.

Chairman Board of Examiners, International Electrical Exhibition:

SIR:—The Examiners in Section XXI (on Fire and Burglar Alarms and Annunciators), respectfully present the following report.

DAVID R. WALKER, (*Ch'n*),
Examiners of Section XXI.

PHILADELPHIA, *December*, 1884.

FIRE AND BURGLAR ALARMS AND ANNUNCIATORS.

EXHIBIT OF THE WESTERN ELECTRIC COMPANY.

The Hotel Fire Alarm and Room Call, exhibited by this company, is designed for the following purposes: When a call is received in the office by means of the annunciator, the clerk, by pressing one of the push buttons, can signify to the guest that the call has been received and will be attended to. Should the clerk desire to ascertain whether a guest is in his room, he can press on the proper button of the room call, and the guest, by pressing upon the button in his room, can signify that he is in. The room call can also be used to call the guests at any time desired; when employed for that purpose, the bell being kept ringing until the guest announces that he is both awake and up, by signaling back to the annunciator, causing the bell in the office to ring and his drop to fall. In case of a fire, by moving a switch, a crank is set in motion and rollers upon the two ends, by pressing upon the push buttons successively, ring the bell in every room.

The chief advantage claimed for this system is that it requires only the same battery as is in ordinary use for the hotel call, and it is therefore subjected to daily tests; but where a large battery is required for the fire alarm, there is a liability that, in time of a fire, from being seldom used, it will be found out of order. While there is quite a similarity in hotel annunciators, in this one the arrangements are novel and the mechanism simple in its construction, so as not to be easily disarranged.

In the Burglar Alarm Annunciator, the indications are made by means of the needle annunciator. By the action of suitably arranged switches it is possible to connect to or disconnect from the alarm, any part of the house, at pleasure; the annunciator and bell can be connected to the alarm if desired, or the annunciator can be connected and the bell not connected, thus giving a silent alarm; or to show whether the strength of the battery is sufficient to work the alarm, it can be connected with the bell alone.

By the system of "Continuous Ringing," the bell rings whenever an opening is made, not only as long as the opening remains but until attention is called to the alarm and the ringing stopped by means of the restoring apparatus. By means of a switch on each machine, the "Continuous Ringing" system can be used, or not, at pleasure.

The chief advantage claimed for the Williams Mechanical Gong is that it requires but a very slight electrical current to release the mechanism, and the hammer being near the centre of the shaft on which it swings, is easily set in motion, so that as it approaches the gong, the centrifugal force carries it into position.

For the Haskins Turtle Gong it is claimed that the pivoting of the armature is such that a very slight electrical current will be sufficient to actuate it. With this is combined the advantage of economy ot space.

EXHIBIT OF THE NOVELTY ELECTRIC COMPANY.

The Novelty Electric Company exhibit the following Fire and Burglar Alarm systems:

The fire alarm exhibited was patented by Mr. Ahearn, of Ahearn & Soper, Toronto, Canada, and is designed as a cheap and economical system for small towns. Signal boxes are located at convenient points: these boxes are in electrical circuit, with electro-magnetic bells, which are designed to be placed in engine houses, stores and private residences. The operation is simple and is as follows: The opening of the signal box door releases a weight, which, dropping, causes an armature to revolve between permanent magnets, which are similar in construction to the magnets and armature of the Bell magneto: this gives an effect the same as turning the crank of a magneto. On the spindle oı the armature, or connected with it, is a small circular circuit breaker, which automatically signals the number of the station from which the signal has been sent upon all the bells with which it may be connected.

The burglar alarms exhibited were patented by D. Rosseau, of New York, and J. D. Lazelle, of New York, and contain the following important features: In addition to the alarm system, they have an attachment by which every door and window that is in circuit can be tested without the noise and annoyance of the bell ringing; this attachment is called a "silent tester." In the case there is also a clock which, besides being an ornamental time piece, automatically and at any hour desired, opens all or any part of the house, and at the same time rings an alarm for the purpose of calling the occupants of a certain room.

Burglar Alarm, No. 2, has all of the above attachments, with additional attachments to awaken different servants, guests and household at different hours.

Burglar Alarm No. 3, in addition to the attachments of No. 1, has the advantage of a gas connection, which works in conjunction with indicators or drops, so that in case a burglar opens a door or window, he not only rings the bell and drops an indicator, but also lights the gas and reveals his exact position.

Burglar Alarm No. 4, merely communicates an alarm without giving any indications from what particular point it comes. In order to locate the point of alarm the switches must be turned on the face of the alarm, when the correct one will stop the ringing of the bell. The annunciators are of the shuttle-drop kind, not complicated nor easily put out of order, and are claimed to be effective.

APPLEGATE'S ELECTRIC FLOOR-MAT ALARM.

This system comprises essentially an electric alarm bell, a mat-carrying circuit, and closing and breaking devices, so that when the mat is subjected to pressure the alarm will be sounded. The mat consists of narrow strips of wood connected to a fabric backing, and on the strip side of the mat is a series of springs which support the mat, there being two separate wires and the springs being securely connected to each wire. When the mat is stepped upon these springs are compressed, contacts are made, and a current is sent through the connecting wires (which are embedded or grooved in the wood) to the bell electro-magnet, so as to sound an alarm. The bell has a switch or lever on the frame, by means of which, when moved, the vibrating adjustments are displaced and the current ceases to flow through the armature spring or circuit breaker, then passes directly through the magnet, and upon the movement of this switch or side lever, it greatly lengthens the stroke of the armature, which is essential when a single stroke only is desired. The same lever that lengthens the stroke switches the current directly through the magnet closing the circuit, attracting and holding the armature. The reverse movement of the lever readjusts the bell as a complete vibrator with a short stroke.

There is also a further improvement, "automatic," in the form of a ratchet wheel which revolves by the movement of the armature by means of a pawl, the wheel revolving upon a projection from the bell frame. The wheel has a pin, or pins, inserted and properly insulated from it. As the armature vibrates, the wheel revolves and one of the projecting pins comes in contact with two delicate springs sending the current directly through the magnet and holding the armature, acting automatically and giving a short sound of the alarm with the circuit still closed at the mat or other circuit-closing devices. When the circuit is broken at the mat it is also broken at the two small springs on the bell ready to repeat the short alarm upon closing the circuit, thereby preventing an annoyance while the distant points may be connected.

A padding is used, in connection with the mat or matting, comprised of four thicknesses of paper, glued together, known as carpet padding pulp paper. Each of the strips of different width; thus, by laying it at the outer edges, graduating the carpet and hiding the mat, and, in addition to the finish, preventing the mat from cutting the carpet or other covering.

The mat exhibited is intended for use on an open circuit, but can be used also on closed circuits.

The advantages claimed for this system are security, portability, cheapness and convenience. The mats may be placed beneath the carpet and the wires entirely concealed so that the burglar has no chance of rendering the device inoperative by cutting the wires, while a few pieces of the matting placed in different portions of the house would provide ample protection. The mat alarm affords the same protection, whether the doors or windows are closed or open, and therefore interferes in no way with the proper ventilation of the house. The system is available as a call for stores, offices, banks, etc., as well as for a burglar alarm. As the mat can be put down and taken up without trouble, and as the wiring is very simple, it can be readily transferred from one house to another. We append a copy of the patents which explain the accompanying diagrams.*

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* Here follow copies of the drawings and specifications filed in the following patents: 195,074, September 11, 1877; 240,939, May 3, 1881, which the committee does not deem it necessary to re-publish.

EXHIBIT OF THE AMERICAN DISTRICT TELEGRAPH COMPANY.

The District Call system may be described as follows: A box contains a clock-work, which, when wound up, by the turning of a crank or handle on the outside of the box revolves a circuit-breaking wheel upon the periphery of which rests a connecting spring. When the crank or handle is placed at the word " messenger " and released, the revolution of the circuit wheel causes the connecting spring to drop into slotted or open spaces and breaks the main circuit and the signal of the box, thus arranged is received at the district or central office upon a relay, the back action of the armature of which closes a local circuit acting upon a bell and register and recording the signal. When the crank is placed at the word " police " and released, the circuit wheel makes two revolutions causing two registrations of the signal.

The several calls for which the box is arranged are determined by the number of times the signal is received at the central office.

It may be noted that all " call " signals end with an even figure to distinguish them from the burglar alarm signals which end with an odd figure. This system of calls being the usual method adopted by all District Telegraph Companies, for signaling from a distant point to a central office. No special claim is made for it excepting as it enters into the arrangement of the following described exhibits:

THE CLOSED CIRCUIT BURGLAR ALARM SYSTEM.

The doors and windows having been connected by closed circuit springs to the burglar alarm box placed in the building, the action may be substantially described as follows:

The box contains the circuit-breaking wheel before described, a pair of magnets to actuate an armature and a pivoted shaft to hold the circuit wheel in check. The main circuit is brought in and connected to each side of the pair of magnets,—after passing through the circuit wheel and connection spring, and, at these points the shunt or wire passing through the building and fastened to the spring, is also connected. When the shunt is closed by the closing of each and every door and window, the clock-work is wound up and the circuit wheel is caught and locked by the pivoted shaft, at the same time a plate drops in front of an opening in the box face and shows the word " set." The main circuit now passes from the point of connection over the shunt, which offering a very much less resistance than the magnets cuts them out so long as the shunt is kept closed. Should any door or window now be opened, and the shunt be broken, the circuit passes through the magnets, attracting the armature which trips or throws off the detaining shaft and releases the clock-work. The magnets having performed their work, are, by a very simple device, cut out of the main circuit, and the circuit wheel and connection spring are alone left in the line circuit.

By the use of a simple device the magnets may be thrown into circuit, the box not being wound up, and should any portion of the shunt be open the armature will be attracted and a clicking sound be heard, which will not be possible if the shunt is closed and intact. The signal of the burglar alarm is transmitted five times. It is claimed that this system is a perfect closed circuit "alarm," by which it is not possible to leave any portion of a building, connected by this method, open or unprotected, as the shunt must be closed in its entirety to wind up and "set" the alarm box.

The protective or cabinet system consists of a wooden case or covering, the inner surfaces of which are lined throughout with wires, which, being securely fastened in both directions upon the surfaces, forms a perfect protection. This case may be used as a cabinet, simply, or as an enclosing case for a safe. It is connected by wire with a central office having special appliances for receiving notice of the closing as well as the opening of the case. It is claimed for this system that it is a perfected method of protecting safes, vaults and rooms by an electric covering which cannot be broken through, cut out of circuit, or in any manner tampered with, after having been closed and placed in connection with a central office, by any one—expert burglar, electrician, or any other person.

THE POLICE SIGNAL SYSTEM OF THE MUNICIPAL SIGNAL COMPANY OF BOSTON.

This system provides means of intercommunication between the policemen on their routes and the commanding officer at the police station, by signaling apparatus designed for the purpose and also by telephone, the latter being used solely as an adjunct to the signaling portion of the system. The exhibit comprises a station house apparatus and a policeman's beat equipped with two signal boxes or stations and a telephone station, the stations being connected with the station house instruments by two metallic circuits, one for signals and the other for telephones. The station house instruments consist of two relays, one on each side of the signal circuit, their armatures controlling two ink recorders after the manner of district or fire alarm telegraphs. One of these recording instruments registers the "on duty," or "patrol" signals of the policemen, while the other only records the "alarm" signals. The signals are regulated by the introduction of a greater or less resistance, the less resistance being used for the patrol and the greater for the alarm signals. The station house is also provided with a transmitter capable of transmitting any one of a hundred numbers, and it is provided with an index dial and pointer for convenience in setting it in position to transmit any desired number. The transmitter itself is of ingenious construction, being a concaved drum, having the circuit controlling contact points for each number grouped thereon longitudinally, the various signals being arranged side by side round the drum. Four revolving arms, moved by a clock-work motor, controlled by detents and having flexible contacts at their extremities, which, when revolved, successively co-operate with the contact points on the concave surface of the drum, close and open a local circuit controlling a pole changer whereby the main battery on the signal circuit is reversed whenever the revolving contact in co-operation with one of the drum contacts, closes the local circuit of the pole changer. The street signal boxes, when their doors are open, expose dials having nine different signals or calls conspicuously displayed thereon, such as "Aid," "Wagon," "Riot," "Ambulance," etc., and should a policeman require "aid," "wagon," or anything inscribed on the dial, he has merely to move an index finger to that desired, and then give the alarm, which causes characters, such as dots and dashes to be transmitted over the circuit and recorded at the police station, indicating to the person in attendance the nature of the aid and the locality where it is wanted. The closing of the door of the signal box restores the indicator to its normal position. Citizens may have keys issued to them, numbered and registered at police headquarters, and they can give a police alarm from any signal station by merely inserting the key in a "citizen's keyhole," underneath the door of the signal box, turning it as far as it will go, and then releasing it, and a policeman can likewise, in an emergency, give a call for assistance in like manner, without being obliged to open a door of any kind.

The telephone stations, as shown in this exhibit, are separate from the signal stations, but they each bear a number to distinguish them from each other, as do also the signal stations. It is claimed that the telephone stations can be combined with the signal stations.

Policemen can send in their " on duty " signal from the signal boxes in rotation, at certain definite times, and these signals are received on the patrol register at the police station, and, at the same time, the transmitter is automatically brought into action and transmits over the circuit whatever number is in position for transmission, ringing it on a bell inside of the street signal box, by means of a polarized magnet and armature, the policeman being informed by the number he hears whether he is wanted at the telephone or at some other signal station.

The chief merits claimed for this system are: complete control of the policemen by their commanding officer; rapid and efficacious communication of policemen and citizens with police stations, and separate and independent recording instruments for alarms and " on duty " signals on a single circuit. It is also claimed that if an " on duty " signal and a " call " signal be given simultaneously that the " call " signal will be registered notwithstanding the " on duty " signal, the interference not affecting the more important, or " call " signal, owing to the higher resistance introduced into the circuit.

The mechanism by means of which the signal boxes are operated was not shown to the committee.

THE PORTER AUTOMATIC ELECTRIC SIGNAL AS A FIRE ALARM SYSTEM.

The principle of the circuit is known as the earth or ground connections; that portion, however, which is outside of the office is metallic, the grounded ends being under control of the operator at the station.

At each end of the circuit there is a system of relays and local signal. On one of the ends there is a rheostat for the purpose of increasing or diminishing the resistance of the circuit. The ordinary method for using this is to " put in " as much resistance on the rheostat end of the circuit as will enable the tension spring of the relay at the outgoing end of the circuit to overcome the magnetic attraction on the armature, thus holding it away from the poles until the resistance in the circuit is reduced when the magnetic attraction will overcome the tension spring and a local alarm is the result. The relay on the rheostat end of the circuit is operated just the reverse of the one at the battery end, the adjustment being made so that the magnetic attraction barely overcomes the tension spring; so that the slightest falling off of magnetic attraction will permit the tension spring to draw the armature back, when the other local alarm system will be operated.

Each signal box has an earth connection, which is brought into use only when the box is operated so that, by giving a signal, a ground is established through the circuit breaking wheel, the circuit being broken by the same operation, as the wheel revolves, the combination giving the number of the box is consecutively made and repeated three times. It is claimed for this system of signaling that on one side the circuit might be entirely destroyed, while the signal would come into the office all right on the other side. It is also claimed that the operator is made aware of the slightest changes in the condition of the circuit and without leaving his station can instantly switch in a reserve battery or even utilize a "ground," "break," or "cross" to do the work of signaling.

EXHIBIT OF PARTICK & CARTER.

The novelty of device, mechanism, etc., which is claimed for the annunciators and alarms in the above exhibit, are:

1. A perforated zinc plate acting as a dial and support for the pointers, and in the smaller size performing the part of tripping or restoring mechanism without any farther mechanism being necessary than a pair of hinges at the top of plate. The plate, or dial on being moved forward, breaks the contact between the pointer and the magnet core; no amount of jar or hard usage will throw this plate out of place or adjustment, a very important point when the rough handling of kitchen and other annunciators is so apt to throw delicately constructed mechanism out of order.

2. The small number and great simplicity of the parts, there being only one magnet and a pivoted needle or pointer necessary for each indicator or number, thus reducing the number of parts to a minimum, the simple pointer doing the work of several parts.

3. In the large or hotel annunciators the same mechanism is employed as in the smaller, with the exception that the dial is stationary,

the tripping mechanism being merely a system or number of brass strips carrying pins projecting through slots in the dial. These pins press the pointer away from the magnet core whenever the trip handle is moved. Only the pointer that is indicating is moved by this arrangement.

4. Owing to the extreme simplicity of this apparatus a very small battery power is required to operate the annunciator.

5. All bells placed in these annunciators are mounted on iron frames, so arranged that it is almost impossible to put them out of adjustment.

6. The needle or pointer can be made of steel or iron, as permanent magnetism is not depended upon to cause it to adhere to the core of the magnet, residual magnetism being sufficient.*

The committee regret that they were not furnished with more lettered diagrams of the exhibits as thereby the explanations could have been more clearly set forth.

In some instances it was found that the persons in charge of the exhibits were not as fully competent to explain the workings thereof as the committee would have desired.

The foregoing report is respectfully submitted by

David R. Walker, *Chairman.*
Wm. Atlee Drysdale, Hugo Bilgram,
David Brooks, Louis H. Spellier,
E. Alex. Scott, Theo. D. Rand.

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* Here follows a diagram of the connection for the Patrick & Carter alarm, which the committee does not think it necessary to reproduce.

TK6
1884m

Philadelphia.

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

OF THE

FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

REPORTS OF THE EXAMINERS

OF

SECTION XXII.

(*SECTION IV—A, CLASSES V, VI, VII OF THE CATALOGUE.*)

8334

Supplementary Report on Meteorological and other Registers.

[ISSUED BY AUTHORITY OF THE BOARD OF MANAGERS AND PUBLISHED AS A
SUPPLEMENT TO THE JOURNAL OF THE FRANKLIN
INSTITUTE, MARCH, 1886.]

PHILADELPHIA:
THE FRANKLIN INSTITUTE.
1886.

[illegible]
TK6
1884.m

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T. C. – June 1, 1904 – G. M. C.
S. S. B. No. 2606

REPORT OF DR. LEONARD WALDO ON THE UNIFORMITY OF TEMPERATURE MAINTAINED IN THE INCUBATOR EXHIBITED BY THE PERFECT HATCHER COMPANY, OF ELMIRA, N. Y.

New Haven, September 1, 1885.

Professor M. W. Harrington, *Chairman of Sub-Committee, Section XXII, on "Self-Registering Instruments."*

Sir:—I submit herewith my report on the steadiness of temperature maintained in the incubator exhibited by the Perfect Hatcher Company, of Elmira, N. Y.

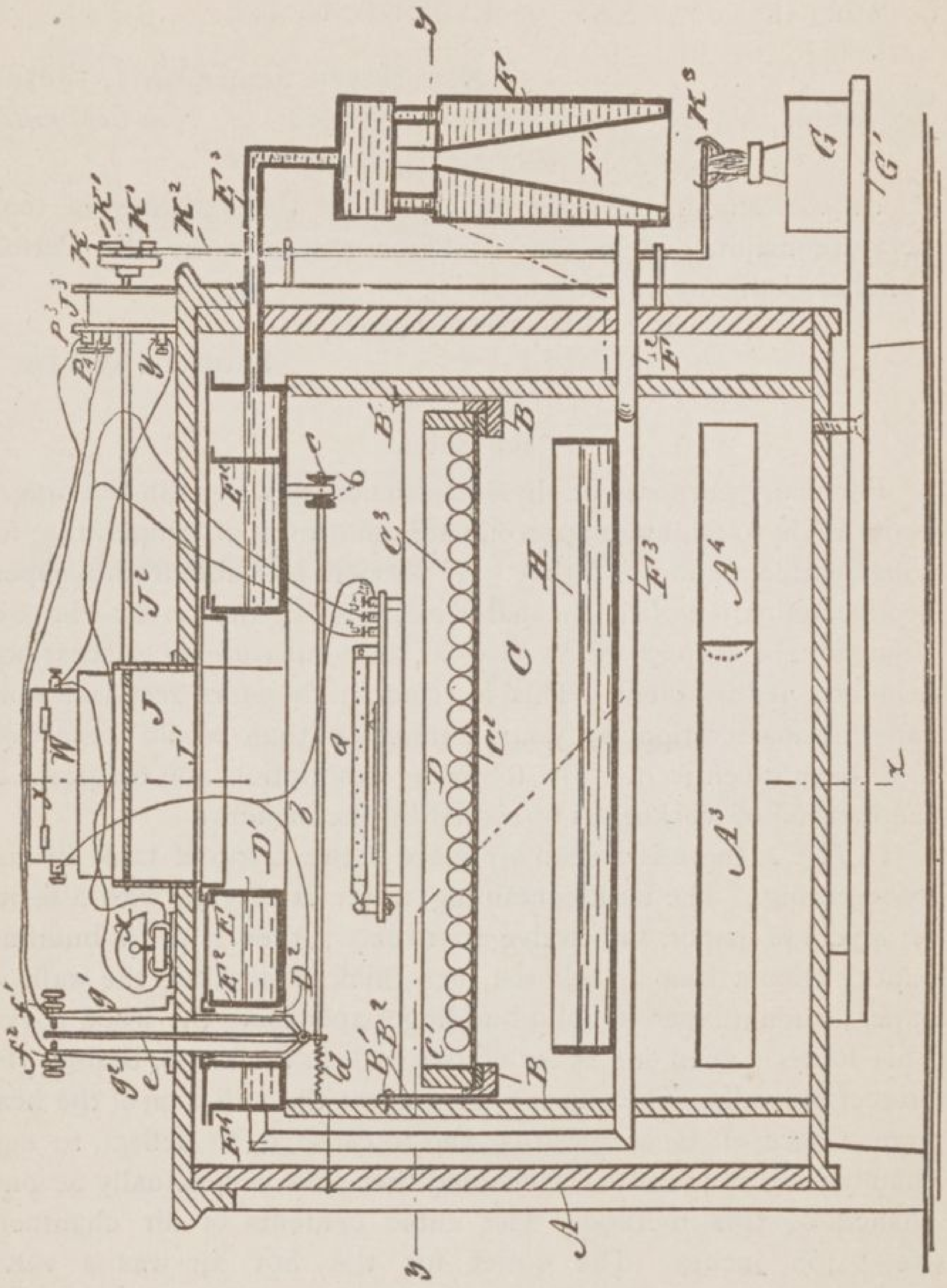
Respectfully yours,

Leonard Waldo.

REPORT.

For many purposes in physical science as well as in the arts, it is desirable to maintain approximate uniformity of temperature for considerable periods of time. It seemed probable from a superficial examination of the incubator exhibited by the Perfect Hatcher Company, of Elmira, N. Y., that a large measure of success had been attained by them. This instrument therefore received more careful consideration by your committee than would otherwise have been given to it. The following description and diagrams of the method of working is furnished by the makers:

In *Fig. 1*, there is a dead air space between top of tank E^2 and wood casing. The tank containing water is covered with a series of layers of paper, say twelve to twenty; then a solid building paper; then a frame work one inch thick to separate the walls of paper; then a layer of solid building paper next the wood cover. This forms a dead air space of one inch in thickness, besides the protecting walls. The object is to prevent the radiation of the heat from surface of tank upwards, and to cause it to deflect to egg chamber below; and it is claimed that this is effectually accomplished by this method. The cubic contents of air chambers are 6,468 inches. The outlet for the hot air was a valve 3 x 12 inches. The inlets for fresh air were four in number, and were 2 x 4½ inches. The openings in this test were 1 x 2½ inches, four in number. At every opening of the large valve, 3 x 12, on top of machine, the lamp flame was decreased to stop heating of water, and was restored to full flame when this valve was closed. The method of applying heat is by a kerosene oil lamp flame or gas flame. This flame heats water in the boiler, which circulates through tank and pipes in such a manner that the heat is evenly distributed throughout the chamber to be heated, etc.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x
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Fig. 1.

PHILOSOPHY OF ITS OPERATION.

Fig. 1 shows a sectional view of the hatcher and all its working parts. On the right end is the boiler, F^1; under it the lamp *G*. Covering the entire top of the machine is the water tank, E^2; the water is heated in the boiler, *E*, passes through the tank in a series of channels, then out and down through pipes F^4 and F^3 back to boiler again to be re-heated. On top of these pipes are the open pans of water; the evaporation from these pans is in proportion to the heat furnished by the pipes—the hotter the pipes are, the more rapid the evaporation from the pans.

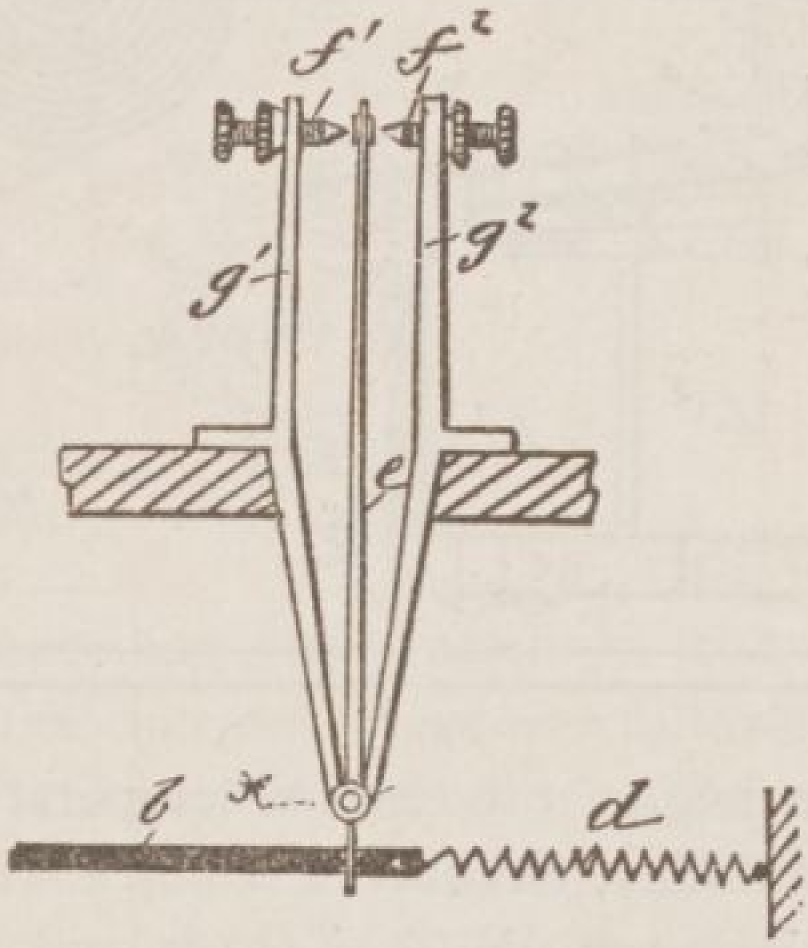

FIG. 2.

The heat is regulated automatically, as follows:

The rod *b* is hung rigidly at the right end, and firmly held in bracket by nuts *c* and *6*; the end at left is attached to bottom of lever *e*; this lever is hung on the points of two screws, carefully adjusted so that the lever is perfectly free in its action. See also *Fig. 2*. This rod is exceedingly sensitive, to every variation of heat, expanding and contracting lengthwise with one-quarter of a degree variation. As it expands with the heat, it throws top of lever over towards regulating screw f^1 (see *Figs. 1* and *2*,) and as it contracts it throws the point of lever over against screw f^2. Whenever this lever comes in contact with either screw, it closes the electric circuit which causes the magnets L^3, *Fig. 3*, to pull down the armature L^2, which releases the fly pin *M*, *Fig 4*, and allows a quarter revolution of the clock, which opens or closes ventilators and turns up and down the lamp flame. When lever *e* comes in contact with screw F^1, it causes ventilators to open and lamp flame to turn down, thus completely checking the heat, and when contact is made with screw F^2 the reverse takes place and heat is restored.

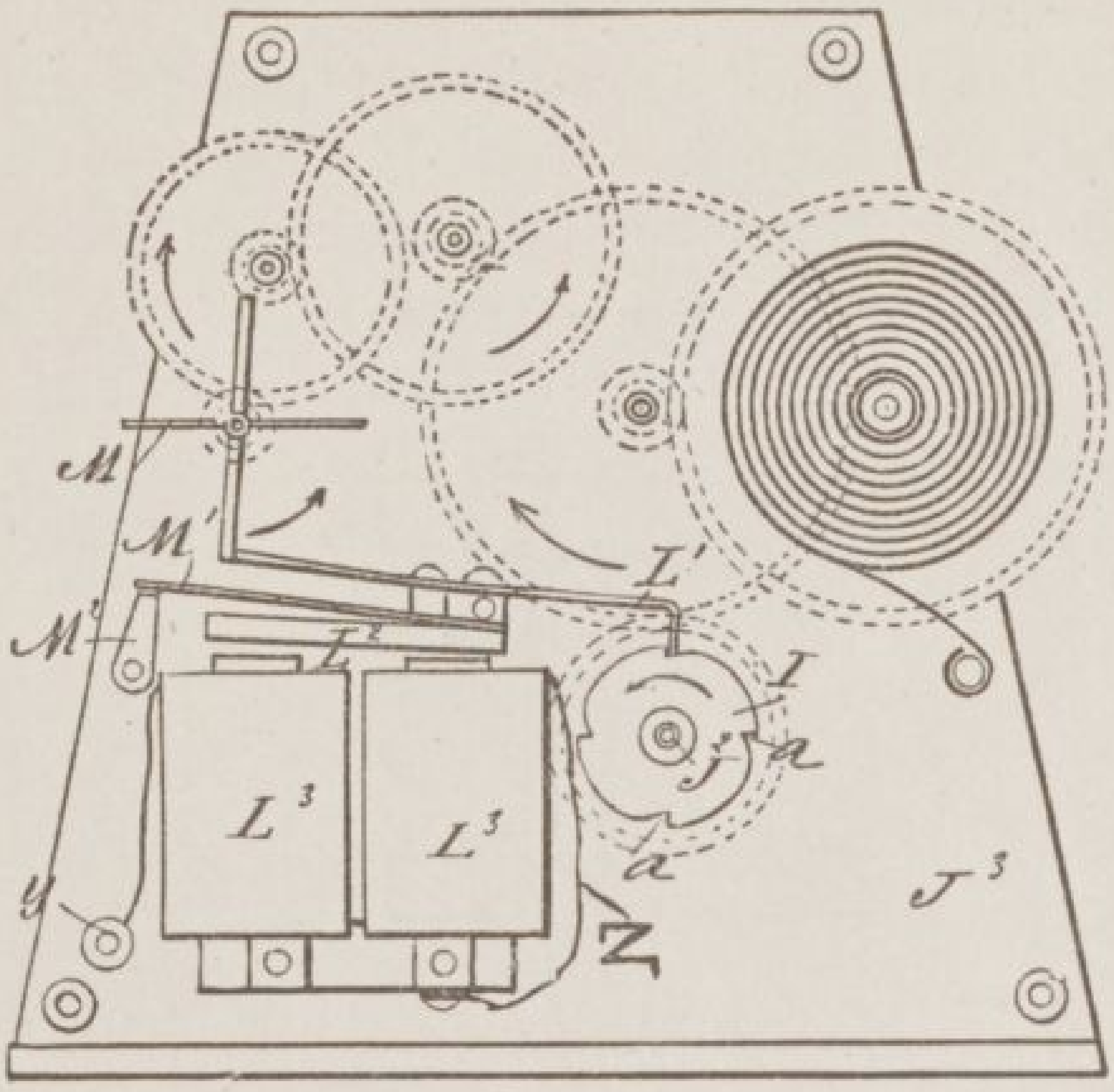

FIG. 3.

Your committee began the test for temperature steadiness on the morning of Thursday, October 2, 1884. There were present Messrs. M. W. Harrington, W. A. Rogers, and the writer. Two thermometers were attached to the rubber bar thermometer *2*, indicated in *Fig. 1*, whose errors did not exceed ·1° F., and whose bulbs were of thin glass and quite sensitive to changes of temperature. The water in the incubator had been exposed to the action of the kerosene lamp for several hours, and the temperature had risen to 105°, or thereabouts. Your committee requested the attendant to set the indicator to maintain a temperature of 101°.

The mercurial thermometers, which may be called III and II for brevity, read as follows during this part of the trial:

Date and Hour, 1885.	Committee Thermometer III.	Condition of Incubator.
October 2d, A M.		
h. m.	degrees.	
9 58·5	105·4	Automatically lowering its temperature to 101° at the request of the committee.
10 12·7	103·8	
10 21·0	102·6	
10 30·3	101·7	

The set screws between which the indicator plays to make and break the circuit operating the clock-work were then set by the attendant; the entire apparatus was then tied by the committee with cotton lamp wicking, and sealed in such a way that the lamp, or any part of the apparatus, could not be changed without breaking the seals, except by the self-acting regulating apparatus, and the following observations made:

October 2, 1884.	Committee Thermometer III.	Committee Thermometer II.	Condition of the Incubator.
A. M.			
h. m.	degrees.	degrees.	
10 30·3	101·7	101·1	Automatically keeping its temperature uniform.
10 45	101·6	100·9	
11 11	101·6	100·9	
11 32	101·6	100·9	
11 45	101·6	101·0	
P. M.			
12 50	101·3	100·5	
1 47	101·5	100·9	

During the preceding observations, a change of about ·1° F. in the reading of the thermometers was followed by the operation of the ventilating fans of the incubator. The opening and closing of these fans took place at intervals varying from one-half minute to two minutes, continuously throughout the trial. Your committee then broke the seals and requested the attendant to increase the temperature to about 109°. This being done, the following readings were made during the afternoon and the succeeding morning, when the seals were finally removed.

1884. October 3d and 4th.	Committee Thermometer III.	Condition of the Incubator.
October 3d. P. M.		
h. m.	degrees.	
2 49	109·5	Automatically keeping its temperature uniform.
3 47	109·0	
9 12	108·5	
October 4th, A. M.		
8 33	109·1	
8 37	109·1	

October 4th, 8·40 A. M., temperature of the outside air, 62° F.

The above observations speak for themselves, and your committee is of the opinion that the apparatus as exhibited and with careful adjustment will maintain a uniform temperature to within 1/4° F., when the temperature in the incubator is higher than that of the surrounding air.

Respectfully submitted,

LEONARD WALDO, *Sub-Committee.*

REPORT OF DR. LEONARD WALDO, SUB-COMMITTEE OF SECTION XXII, ON THE EXHIBIT OF METALLIC THERMOMETERS MADE BY THE STANDARD THERMOMETER COMPANY, OF PEABODY, MASS.

New Haven, September 1, 1885.

Professor M. W. Harrington, *Chairman of Sub-Committee on Registering Meteorological Instruments, Section XXII.*

Sir :—I submit herewith my report to you on the exhibit of the Standard Thermometer Company, of Peabody, Mass., made at your request.

Very respectfully yours,
Leonard Waldo.

REPORT.

The limitations of mercurial and other thermometers are felt in many of the processes of the arts. The boiling and freezing points of mercury being so near together, and the nature of glass rendering it so fragile, and so liable to softening near the boiling point of mercury, combine to render some substitute for the mercurial thermometer highly desirable in many cases.

Your committee, therefore, with your consent, decided to give as thorough an examination into the performance of the metallic thermometers exhibited, as the limits of an extemporized laboratory would allow.

The exhibited thermometers consisted essentially of a coiled cylindrical spiral, the material of which was composed of laminated brass and steel, united by silver solder.

This cylindrical coil is about 1·5 inches long, about ·6 of an inch in diameter, each coil having a width of ·1 inch, and making about twelve turns throughout its length. A change of temperature will, of course, cause an extension of a free end of such a coil, and this extension is magnified by a rack and pinion, which gears the indicator to the free end of the coil.

As constructed by this company, the apparatus is simple, the adjustment of the hand which serves as an indicator, and which moves over a circular dial, is easily effected, and your committee is of the opinion that the indications would be consistent with themselves permanently, so far as liability to get out of adjustment is concerned.

The hand which serves as the temperature indicator, moves over a clearly graduated dial, and the entire instrument is cased in a metallic box, and made to hang in any position.

Two metallic thermometers were selected for careful examination; they were marked Nos. 22 and 23. The hands moved over the dials smoothly, without hitching and in the open air had the usual agreement with mercurial thermometers hung in neighboring positions which is expected of reputable mercurial thermometers.

A water-comparator consisting of a rectangular box holding several gallons of water and provided with heating and stirring arrangements was rigged up in a neighboring building, and the two metallic thermometers were immersed in the water in connection with a number of precision thermometers. After a thorough agitation of the water, the thermometers were read in such a series that the observer began at the left hand end of the row of thermometers standing in the comparator and read to the extreme right. Then making a second reading at the extreme right, the thermometers were then read in an inverse order. The times at the beginning and end of the entire series being noted and the intervals between the readings of the thermometers being practically the same, it is assumed that the means of the thermometer readings correspond to the mean of the observed times.

This is not rigorously true, since the radiation coefficient of the comparator and of the thermometer is not taken into account. Its accuracy is in keeping with the general accuracy to be attained in such apparatus as we were able to devise during the exhibition. Professor Harrington made the record, and occasionally verified the thermometer readings. Professor Rogers was present during a part of the test.

The standard thermometers inserted in the comparator consisted of two short standards made by Hicks, of London, graduated to ½° Fahrenheit, 1° F. = 1·8 mm. The first thermometer of the two reading up to + 40° F., and the second reading to + 103° F.

The corrections of these standards were determined by comparison with the Yale College Observatory standards to be at

Degrees F.	*Degrees F.*
32	0·0
52	0·0
72	+ 0·1
92	0·0

A third standard introduced was one of the standards issued by the Yale Observatory, graduated in C. degrees to $\frac{1}{5}$° C., and having 1° = 4·7 mm. It is marked "Yale Observatory Standard 53.," and I am indebted to Mr. O. T. Sherman, of the Yale Observatory Thermometric Bureau, for the following system of corrections to be applied to its scale.

Degrees C.	*Degrees C.*
0	— 0·04
5	— 0·007
10	+ 0·043
15	+ 0.028
20	+ 0·016
25	+ 0·025
30	+ 0·073
35	+ 0·130
40	+ 0·074

The following observations were made:

Observed Readings of the Standard Mercurial Thermometers: "W. O. I.," "W. O. II.," "Y. O. 53," in a Water Comparator with the Metallic Thermometers marked "No. 22" and "No. 23."

	Date and Time of Comparison.	Reading of W. O. I.	Reading of W. O. II.	Reading of Y. O. 53. (Centigrade.)	Reading of No. 23.	Reading of No. 22.	Y. O. 53, reduced to Fahr.	Y. O. 53, correction in Fahr. degrees.	W. O. I. and W. O. II., correction.
	1885. October 3d. *h* *m.*	degrees.	degrees.	degrees.	degrees.	degrees.	degrees.	degrees.	degrees.
1	12 47·8	26·9	. . .	— 2·55	27·8	27·0	27·41	. . .	. . .
	12 51·1	27·1	. . .	— 2·50	27 8	27·1	27·50	— 0·06	0·0
2	12 53·4	27·05	. . .	— 2·60	27·9	27·1	27·32	. . .	. . .
	12 56·9	27·15	. . .	— 2·60	27 9	27·1	27 32	. . .	. . .
3	12 58·8	27·15	. . .	— 2·50	28·1	27·3	27·50	. . .	. . .
	1 2·2	27·35	. . .	[— 2·20]	28·2	27·3	[28·04]	. . .	. . .
4	1 3·8	27·4	. . .	— 2·40	28·2	27·6	27·68	. . .	. . .
	1 7·2	27·5	. . .	— 2·40	28·2	27·6	27·68	. . .	. . .
5	1 10·4	27·6	. . .	— 2·15	28·3	27·6	28·13	. . .	. . .
	1 14·2	27·55	. . .	— 2·35	28·3	27·6	27·7	. . .	. . .
6	1 35·9	. . .	38·25	+ 3·55	39·20	38·70	38·39	. . .	. . .
	1 39·7	. . .	38·38	+ 3·60	39·20	38·70	38·48	+ 0 08	0·0
7	2 5·1	. . .	68·80	20·40	70·5	68·9	68·72	. . .	. . .
	2 10·2	. . .	68·70	20·40	70·6	68·9	68·72	+ 0·03	+ 0·1
8	2 16·5	. . .	68·60	20·34	70·3	68·7	68·59	. . .	. . .
	2 20·1	. . .	68·55	20·30	70 3	68·7	68·54	. . .	. . .
9	4 11·9	. . .	89·40	31·65	91·9	89·0	88·97	. . .	. . .
	4 14·7	. . .	89·10	31·60	91·9	89·0	88 88	+ 0·13	0·0
10	4 15·2	. . .	89 10	31·60	91·9	89·0	88·88	. . .	. . .
	4 18·5	. . .	89·05	31·55	91·9	89·0	88·79	. . .	. . .
11	4 19·0	. . .	89·00	31·53	91·9	89·0	88·75	. . .	. . .
	4 20·3	. . .	89·05	31·50	91·9	89·0	88·70	. . .	. . .
12	4 54·2	. . .	69 05	20·60	72·3	69·2	69 08	. . .	. . .
	4 56·2	. . .	69·05	20·63	72·3	69·2	69·13	+ 0·03	+ 0·1
13	4 57·2	. . .	69·05	20·60	72·3	69·1	69·08	. . .	. . .
	4 59·0	. . .	69·05	20·62	72·3	69 1	69·12	. . .	. . .

Taking the means of each set, and applying the corrections indicated in the last two columns, we have the following table, showing the corrected standard readings in Fahrenheit degrees as compared with the readings of the metallic thermometers, Nos. 23 and 22:

Number of the Pair.	Mean of the Times.	Mean of the W. O. Thermometer in Fahr.	Mean of Y. O. 53 in Fahr.	Corrected Mean W. O. Thermometer.	Corrected Mean Y. O. 53.	Mean of the Mercurial Standards.	Mean of No. 23.	Mean of No. 22.
	h. m.	degrees.	degrees.	degrees.	degrees.	degrees.	degrees.	degrees.
1.	12 49·4	27·00	27·45	27·00	27·39	27·20	27·80	27·05
2.	12 55·2	27·10	27·32	27·10	27·26	27·18	27·90	27·10
3.	1 0·5	27·25	[27·50]	27·25	27·44	27·35	28·15	27·30
4.	1 5·0	27·45	27·68	27·45	27·62	27·54	28·20	27·60
5.	1 12·3	27·57	27·91	27·57	27·85	27·71	28·30	27·60
6.	1 37·8	38·31	38·43	38·43	38·51	38·47	39·20	38·70
7.	2 7·6	68·75	68·72	68·85	68·75	68·80	70·55	68·90
8.	2 18·3	68·57	68·57	68·67	68·60	68·63	70·30	68·70
9.	4 13·3	89·25	88·92	89·25	89·05	89·15	91·90	89·00
10.	4 16·8	89·07	88·83	89·07	88·95	89·01	91·90	89·00
11.	4 19·7	89·03	88·72	89·03	88·85	88·94	91·90	89·00
12.	4 55·2	69·05	69·10	69·15	69·13	69·14	72·30	69·20
13.	4 58·1	69·05	69·10	69·15	69·13	69·14	72·30	69·10

From the above we readily deduce the corrections to be applied to Nos. 23 and 22 to reduce their face readings to the true temperature of the comparator as follows:

Number of Observations.	Point of Ther. Scale F.	Correction to No. 23.	Correction. to No. 22.
	degrees.	degrees.	degrees.
5	27·4	— 0·65	+ 0·09
1	38·5	— 0·73	— 0·23
2	68·7	— 1·71	— 0·08
3	89·0	— 2·87	+ 0·03
2	69·1	— 3·16	+ 0·04

Analyzing the above results, we see that No. 23 fails to return to its agreement with the mercurial thermometers at 70°, after it had been compared at 90°, by 1·4°.

No. 22, however, shows a remarkable agreement with the scale of the mercurial thermometers both ascending and descending. With the exception of its deviation at 40°, which is still less than ¼° F., there seems to be no deviation of its scale as great as ·1° F.

This, for commercial purposes, is a practical agreement with the perfect mercurial thermometer at ordinary temperatures.

It is not improbable that the coincidence extends in practical agreement with the Fahrenheit scale to some degree above the point of boiling water. On this point, however, your committee has had no opportunity to satisfy itself.

The instruments impressed your committee with their neatness of design and legibility of dial. They seemed peculiarly appropriate for ordinary air temperature use, and have the merit of revealing the temperature at a glance from any point of an ordinary sized room. Your committee was informed that display thermometers of large size were prepared by the same company which were legible at half a block's distance.

Respectfully submitted,

LEONARD WALDO,

Sub-Committee of Section XXII.

TK6
1884 m

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

REPORT OF EXAMINERS
OF
SECTION XXIII.

ELECTRO-MEDICAL APPARATUS.

8334

Philadelphia.

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

OF THE

FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

REPORTS OF THE EXAMINERS

OF

SECTION XXIII.

(*SECTION IV-A, CLASS VIII, OF THE CATALOGUE.*)

Electro-Medical Apparatus,

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PHILADELPHIA:
THE FRANKLIN INSTITUTE.
1886.

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1884m

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r.c. – June 1, 1904 – S.M.C.
G.S.B. Nov. 26 '06

1884–INTERNATIONAL ELECTRICAL EXHIBITION–1884

FRANKLIN INSTITUTE, Philadelphia, Pa.

REPORT OF EXAMINERS.

SECTION XXIII.—ELECTRO-THERAPEUTIC APPARATUS.

To the Board of Managers of the FRANKLIN INSTITUTE:

GENTLEMEN:—I have the honor to transmit herewith the report of Section XXIII, upon "Electro-Therapeutic Apparatus."

Respectfully,

M. B. SNYDER,
Chairman Board of Examiners.

PHILADELPHIA, September, 1885.

PROF. M. B. SNYDER,
Chairman Board of Examiners, International Electrical Exhibition:

DEAR SIR:—I have the honor to transmit the report on "Electro-Therapeutic Apparatus," as embraced under Section XXIII.

I remain yours respectfully,

HARRISON ALLEN,
Chairman Section XXIII.

PHILADELPHIA, September 16, 1885.

REPORT.

The committee has the honor to report:

That the first exhibit examined, was that of Mr. Otto Flemming, 1009 Arch Street, Philadelphia.

In this exhibit are shown an elaborate sixty cell cabinet battery; a wall cabinet for attachment to a stationary gravity battery; a thirty cell combined galvanic and faradic portable battery; a twenty cell galvanic battery; four sizes of faradic batteries; pedal rheotome; unpolarizable electrodes, etc.

EXHIBIT A.

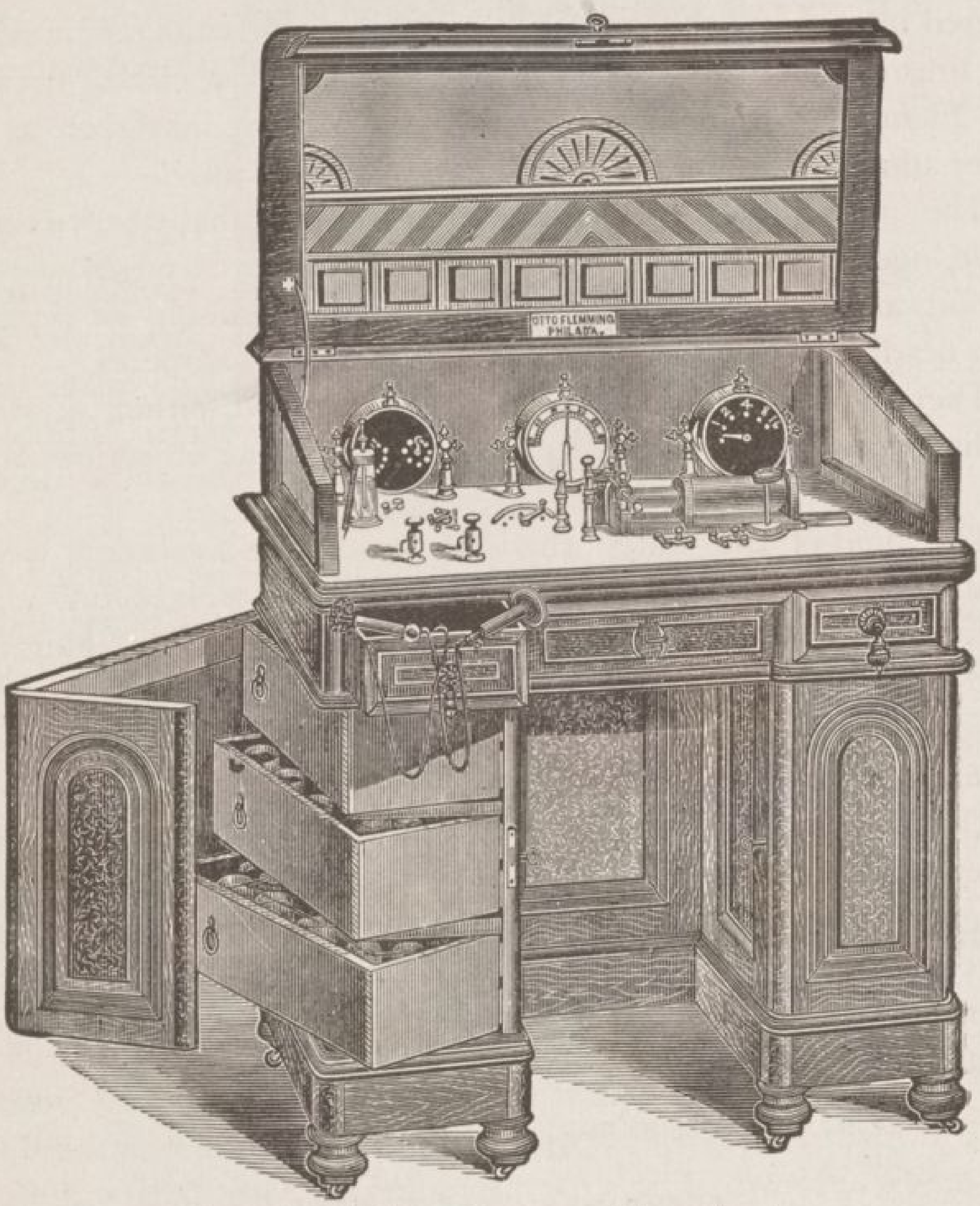
FLEMMING'S CABINET BATTERY (SIXTY CELL.)

The cells of the battery are described by the manufacturer as follows: The elements are composed of zinc and carbon, the latter mixed with peroxide of manganese, granulated and placed in a glass jar to fill one-third of its capacity. In the centre of the jar is placed a glass tube, also filled with the carbon-manganese mixture, and a carbon rod with platinum wire connection (anode) so that the mixture in the centre glass tube is in unbroken contact with the mixture in the outer glass jar. A diaphragm is formed by tightly packing paper pulp on top of the carbon-manganese mixture, which is covered with a saturated solution of ammonium chloride and a zinc ring for cathode.

The objections to the modified Leclanché cell used by Mr. Flemming, are that it exposes too much surface for evaporation and is unnecessarily complicated in structure. The committee does not believe that the modifications are improvements, but the cell was referred for examination to Committee 14, from whose report the following figures are extracted: Cell No. 1, electro-motive force, 1·45 volts; internal resistance, 11· ohms; current strength in ampères at intervals of minutes at the start, ·12; after two minutes ·09. Cell No. 2, electro-motive force, 1·39 volts; internal resistance, 11.

The key-board of the cabinet battery contains an automatic mechanical rheotome, for interrupting the galvanic current, one, two, four, eight, or sixteen times a second; a galvanoscope, a wire rheostat, formed of a series of Siemens' resistance coils, a Du Bois-Reymond coil, with rapid and slow interruptions to the faradic current; the outer secondary helix being moved by a governing screw, thus easily adjusting the currents. There is also a watre rheostat, furnishing resistance to the faradic current, and a commutator, changing the polarity of either the galvanic or the faradic current. A Grenet cell furnishes power for the faradic apparatus.*

The key-board of the faradic coil is well deserving of unqualified commendation. The special points to be commended are the appliances chosen for slow and rapid interruption of the faradic current, which are superior to any others examined by the committee, in that they give a much greater range in the rapidity of


OTTO FLEMMING PHILAD'A.

Sixty-Cell Cabinet Battery. (Flemming.)

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* The descriptions of apparatus furnished by the committee, are usually modifications, or condensations, of those given by the manufacturers themselves.

movement, and are more rapidly and easily adjusted. The slowest rate obtained was forty per minute, whilst in rapidity, the slow rheotome could be made to approximate that of the rapid spring rheotome. The regulating screw of the faradic coil is a decided convenience, and the commutator is to be commended as durable and not likely to give trouble by getting out of order, but is considered inferior to the modification of the pole changer (in which the tires on the discs extend on one-quarter of a circle) used by Mr. Flemming on his portable galvanic battery, inasmuch as the latter admits of a more perfect break in the circuit.

The galvanoscope, which is useful to show that the circuit is made, does not afford any accurate measure of the power of such current, and in the complete galvanic table, it should be replaced by a dead-beat galvanometer, calibrated in milli-ampères.

There are two rheostats on the key-board, either of which ought to be so arranged as to be sufficient. The objection to the wire rheostat is its expense.

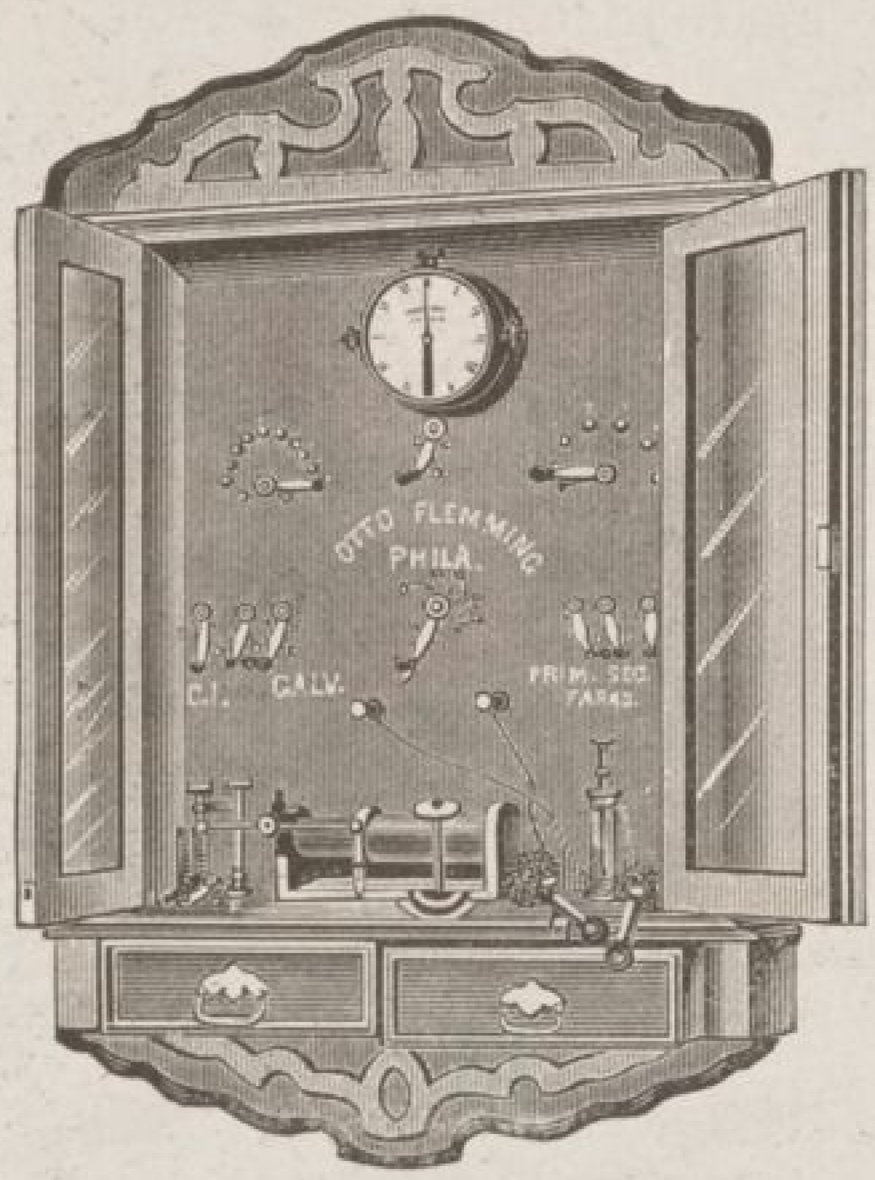
The fluid of the water rheostat should be a solution having greater conductivity than water; because water is so bad a conductor, that in the practical use of the simple water rheostat, it is almost impossible to avoid shocks when the metal conductors are brought into contact. The same rheostat should be used for both currents.

The clock-work rheotome or current interrupter of the galvanic current is condemned as making too prolonged contacts, as being very liable to work irregularly and as offering but a limited range of rate of interruption. It is recommended that the excellent faradic interrupter to be found in the wall cabinet of Mr. Flemming be adopted here also.

EXHIBIT B.

FLEMMING'S WALL CABINET.

In a handsome walnut case, 40 inches high 25 inches wide and projecting 7 inches from the wall is contained a galvanoscope, a commutator, a Du Bois-Reymond coil with rapid and slow interrupter and a contrivance by which the slow rheotome of the Du Bois-Reymond coil can be used to interrupt the galvanic current. There is also a rheostat for both currents and appropriate switches. The key-board of this wall cabinet seems superior to that of Exhibit **A**, in that the water rheostat is adapted to both currents and the rheotome automatic. A very valuable feature in this rheotome is that it gives brief periods of current passage with long interruptions. The water rheostat should undergo the modifications spoken of under Exhibit A. On account of the small space which it occupies and the ease with which it is kept neat, we believe that this wall cabinet is superior to the ordinary table form of keyboard.



Wall Cabinet. (Flemming.)

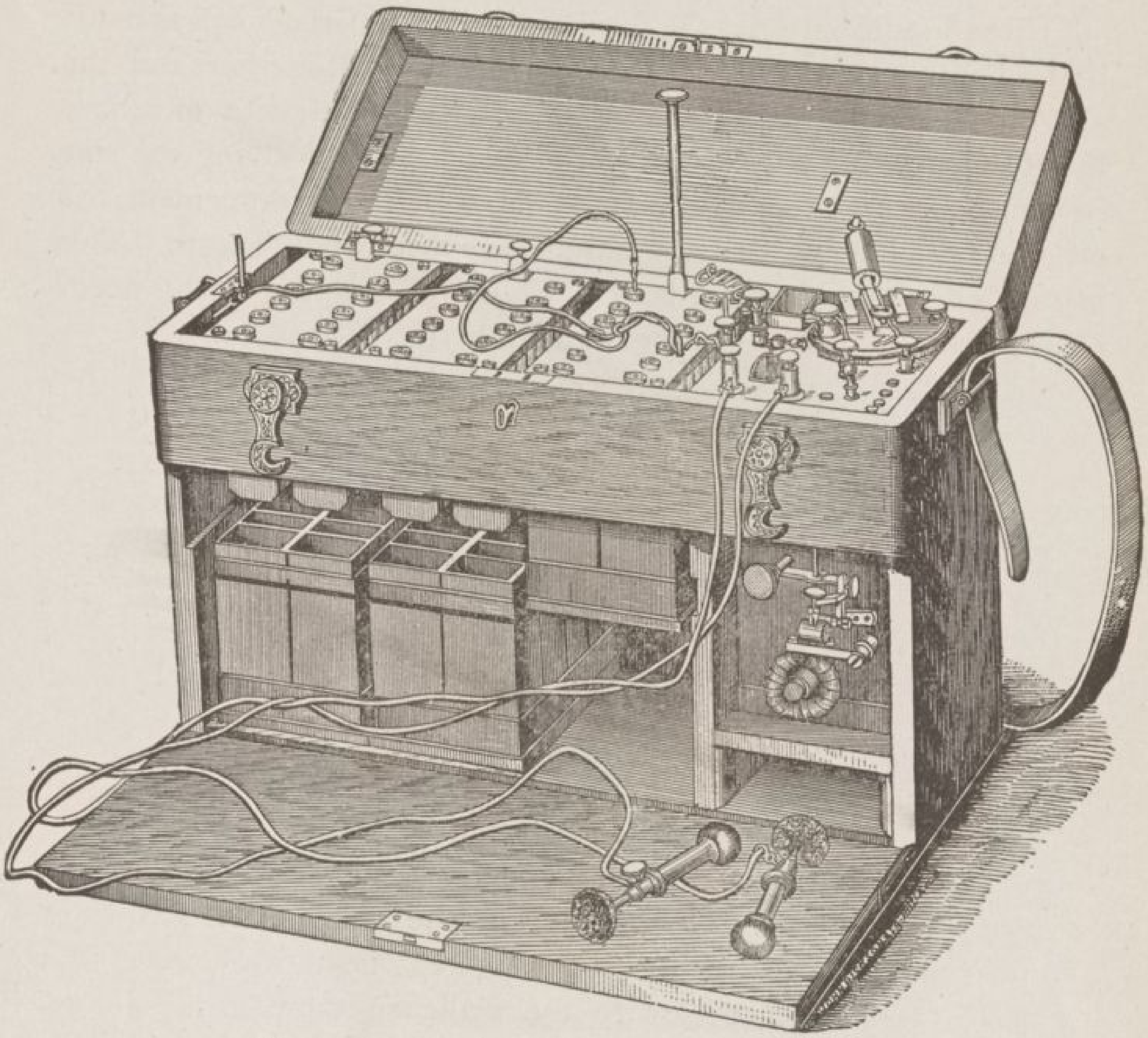
EXHIBIT C AND D.

FLEMMING'S THIRTY-CELL COMBINED BATTERY. FLEMMING'S TWENTY-CELL CONSTANT CURRENT GALVANIC BATTERY.

Both of these batteries are founded on the well-known Stohrer battery, much modified in its mechanical arrangements. It does not seem necessary to give a detailed description of them. Suffice it to say that each is supplied with a hydrostat, which is a rubber-cushioned sliding board, that is kept pressed down on the cells, when the battery is closed and serves to prevent spilling.

In Exhibit C, there is conjoined with the battery a faradic apparatus, provided with both rapid and slow interrupters, which is substantially the No. 3 faradic battery of the same exhibitor.

These batteries in their general mechanical arrangement, and remarkable excellency of workmanship seem to the committee to



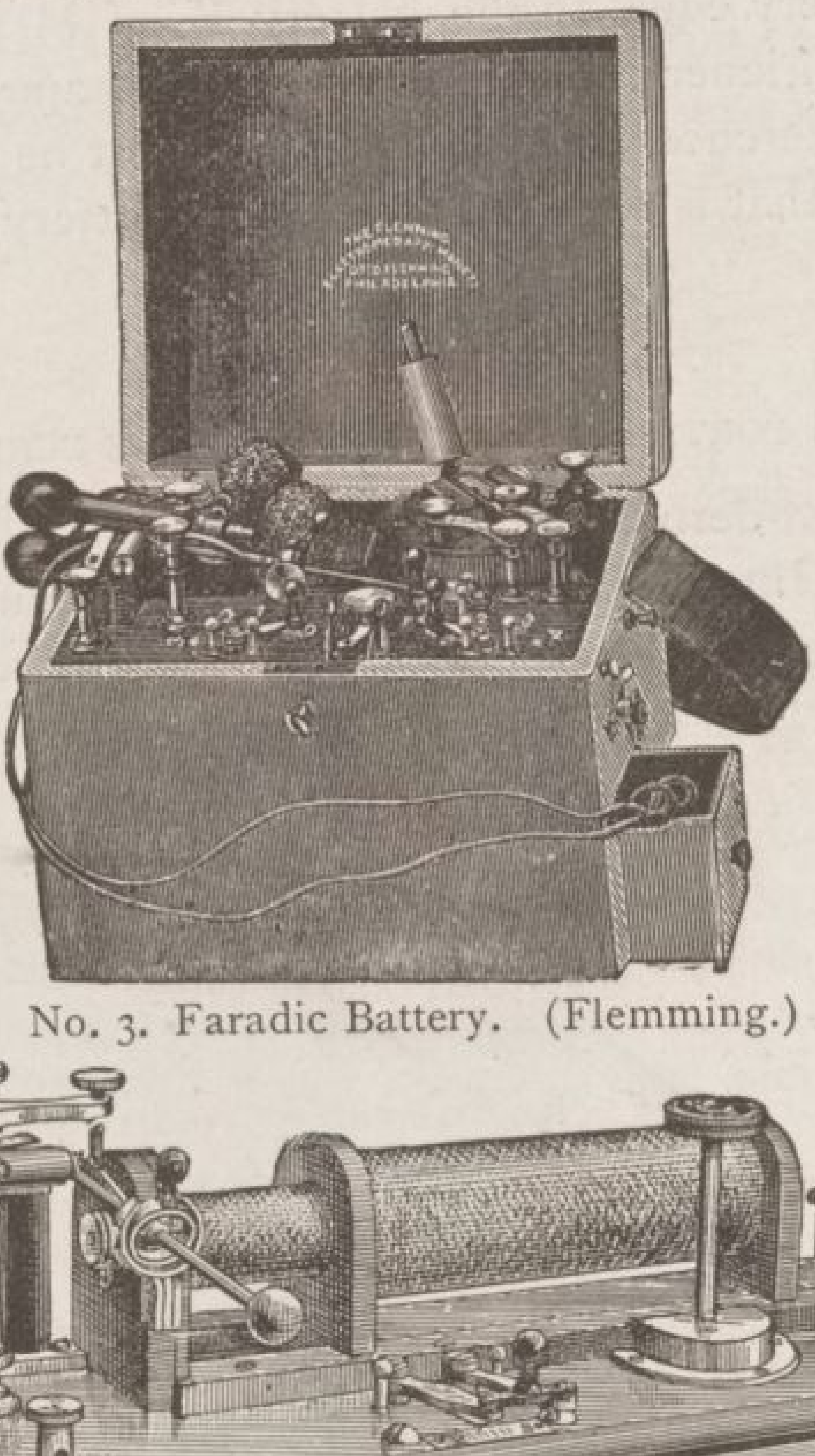
Thirty-Cell Combined Battery. (Flemming,)

be the best forms of the portable bichromate batteries invented, but in practice they, like all other batteries of their character, are open to serious objections. Among these are the highly corrosive nature of the liquid employed, the closeness of the connections to this fluid, the great ease with which splashing occurs, allowing these connections to become corroded and the fact that the joints by any but the most careful handling are very apt to become loose and allow spilling.

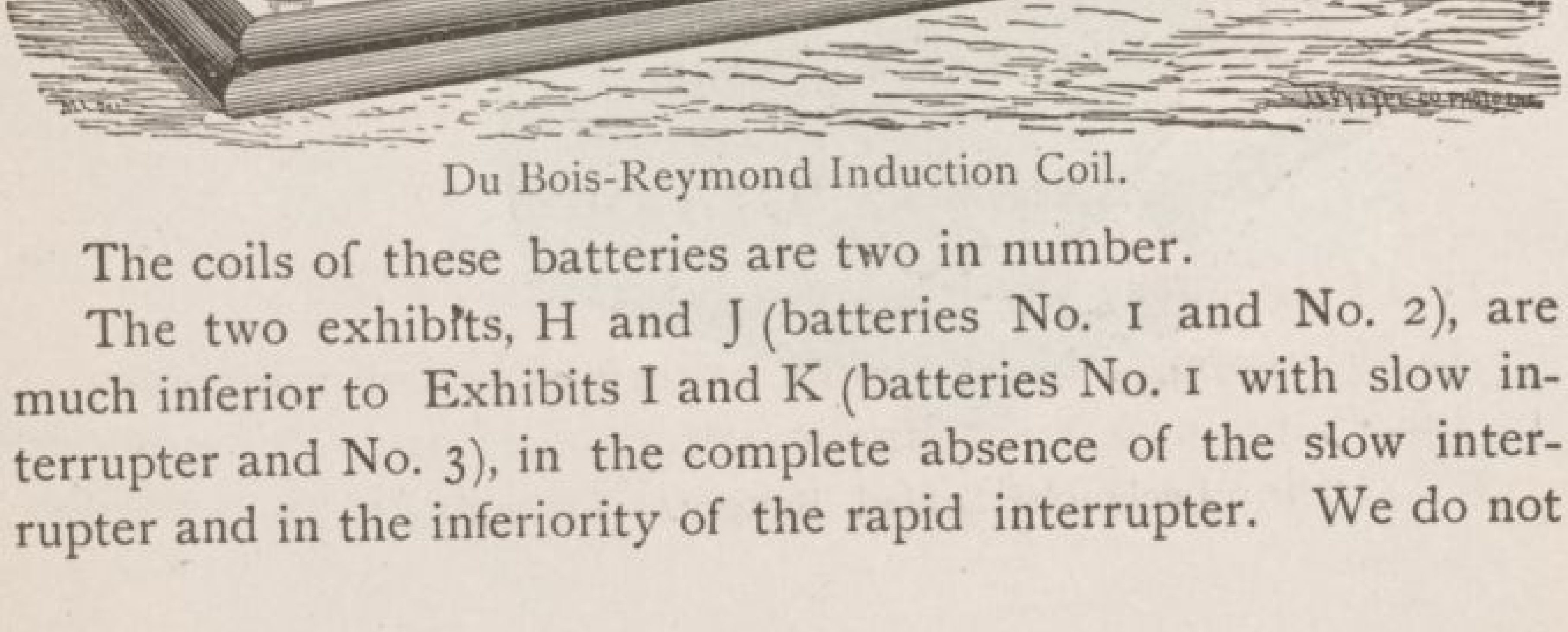
EXHIBITS H, I, J AND K.

H.—Flemming's No. 1 faradic battery,
I.—Flemming's No. 1 faradic battery with slow interrupter.
J.—Flemming's No. 2 faradic battery,
K.—Flemming's No. 3 faradic battery.

These faradic batteries are furnished with the Grenet cell so made that when not in action, the zinc is raised out altogether and the aperture through which it passes securely covered with a rubber hydrostat, making the cell perfectly fluid tight and saving the zinc in transportation or in case of an upset. By this arrangement, the cell can be filled and the zinc immersed for its whole length. This form of cell the committee believe to be well adapted to the needs of the practitioner and commend it highly.



No. 3. Faradic Battery. (Flemming.)



Du Bois-Reymond Induction Coil.

The coils of these batteries are two in number.

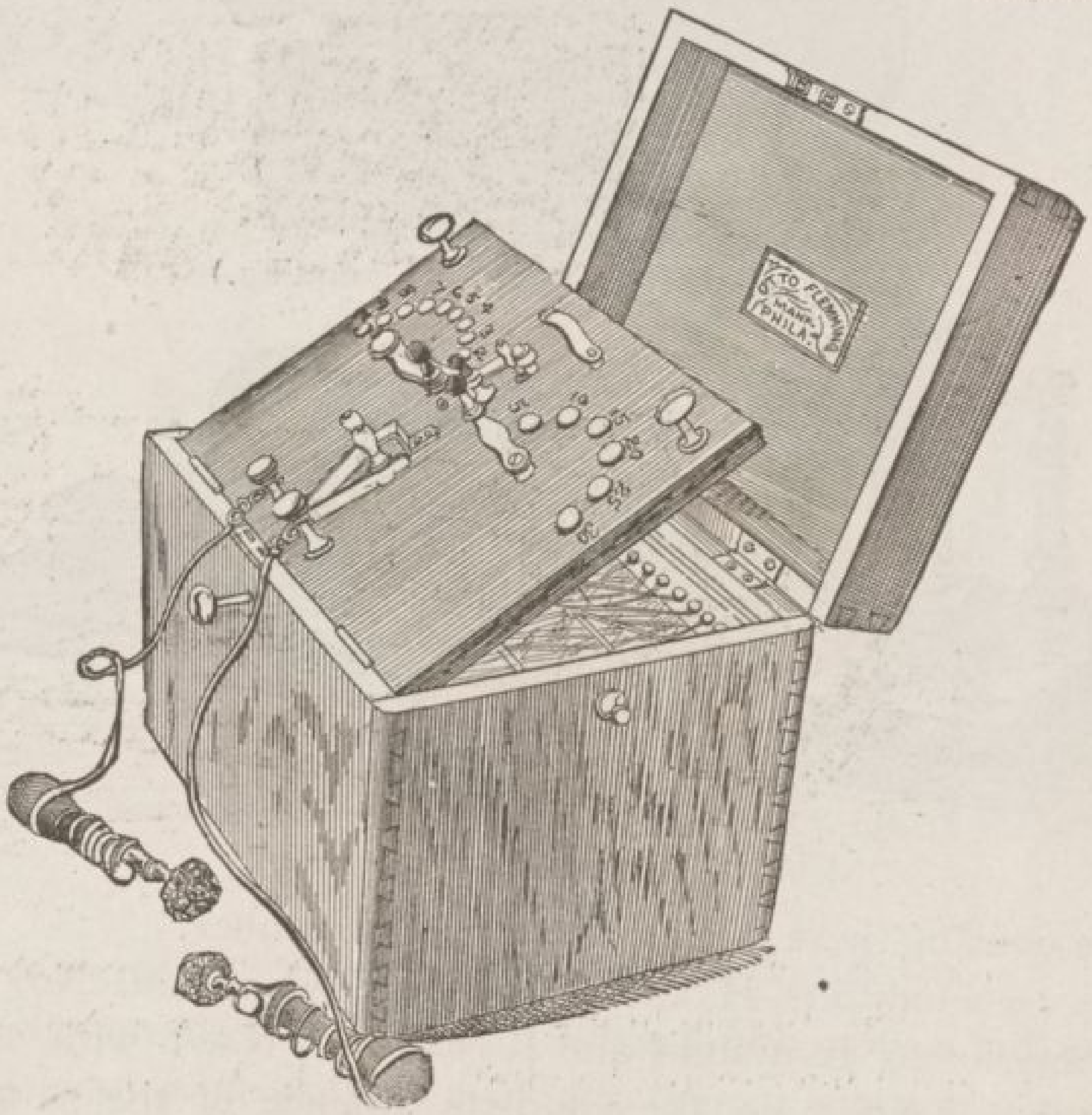
The two exhibits, H and J (batteries No. 1 and No. 2), are much inferior to Exhibits I and K (batteries No. 1 with slow interrupter and No. 3), in the complete absence of the slow interrupter and in the inferiority of the rapid interrupter. We do not believe that either of these batteries is adapted for use in the physician's office.

Batteries I and K are furnished with interrupters similar to those on which we have commented in speaking of the cabinet battery. In the ease with which the current can be graduated, in the greater power derived from longer coils, in freedom from pretence, in excellency of workmanship, in convenience and general adaptability to the exigencies of daily practice, we know of no faradic battery equal to the battery K of Mr. Flemming; but for many practitioners, the lightness and cheapness of battery I, will give it preference, and the occasions must be rare in which it will not do all that is required of a faradic battery.

EXHIBIT M.

TWENTY-CELL PORTABLE SEALED CONTINUOUS CURRENT BATTERY.

This battery derives its current from a modification of the Leclanché element similar to that described in connection with the cabinet battery (Exhibit A), but in somewhat more compact form.



Leclanché Sealed Battery. (Flemming.)

The cells of this battery were referred to Committee 14, from whose report the following figures are extracted: Cell No. 1, E. M. F., 1·07 volts; internal resistance, 8 ohms; current strength at setting up, ·13 ampère, after one minute ·09, after three minutes ·07. Cell No. 2, E. M. F., 1·46 volts; internal resistance, 13·5 ohms.

The key-board of this battery is furnished with a galvanoscope, a commutator and an arrangement for current selection, similar to that of the cabinet battery of the same manufacturer.

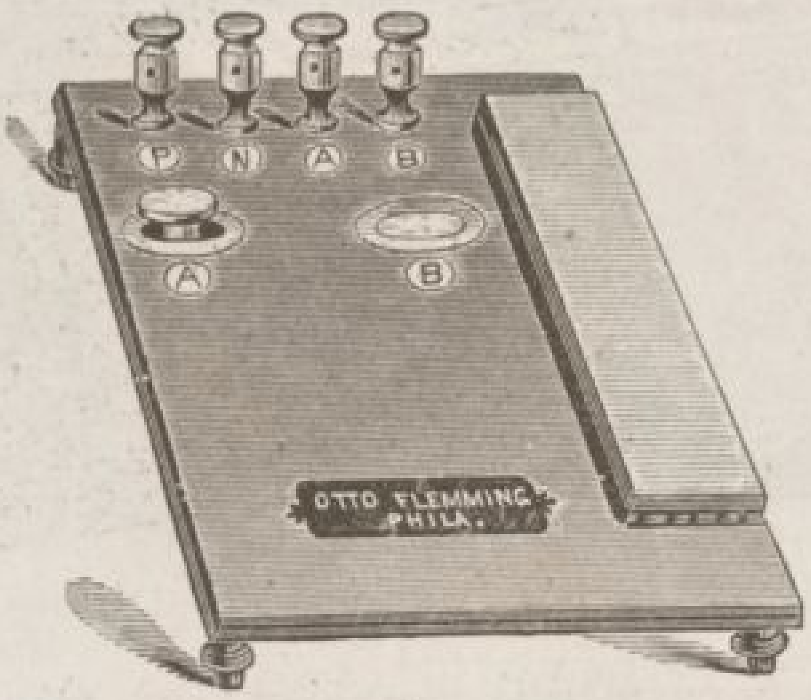
In the absence of corrosive fluid and in permanency and constancy, this battery is much superior to any sulpho-chromate battery. To make it satisfactorily portable would require only that the mechanical arrangement be so altered as to close the cells more perfectly. To adapt it to the full range of medical uses, would require a distinct increase in the number of its elements. In its present form the battery weighs fifteen pounds.

In order to determine the exact value of this battery, the elements were referred to Section XIV.

EXHIBIT N.

MORRIS-LEWIS PEDAL RHEOTOME AND COMMUTATOR.

This instrument is designed to enable the electro-therapeutist to break the current regularly without the aid of the automatic rheotome or a spare hand. We believe that it satisfactorily accomplishes its object.



Pedal Rheotome and Commutator. (Flemming.)

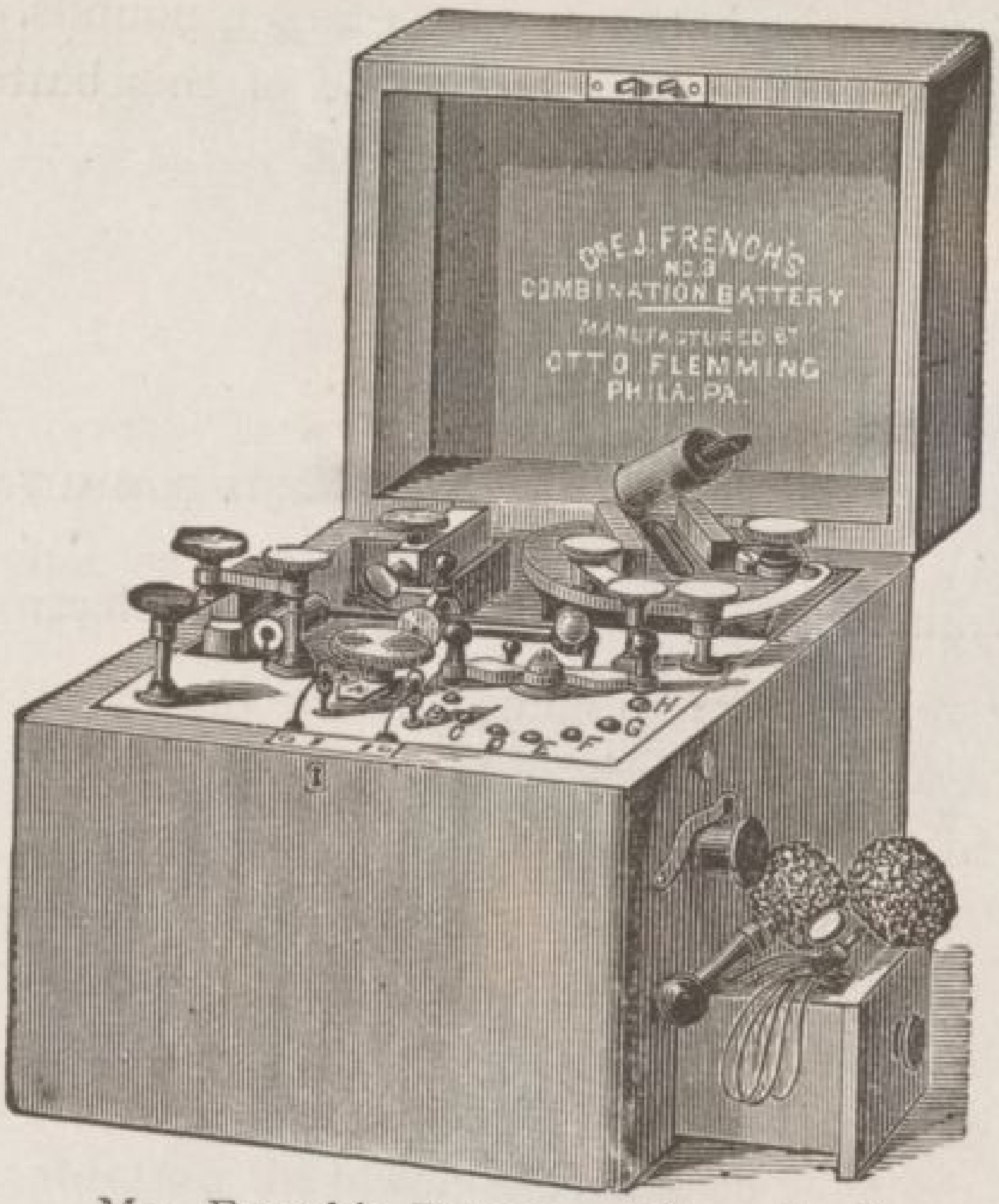
EXHIBIT O.

UNPOLARIZABLE OR HOMOGENEOUS ELECTRODES.

These are the well known unpolarizable electrodes of Du Bois-Reymond. They are well made, but seem to be better adapted to physiological research than the needs of practical medicine.

MRS. FRENCH'S BATTERY.

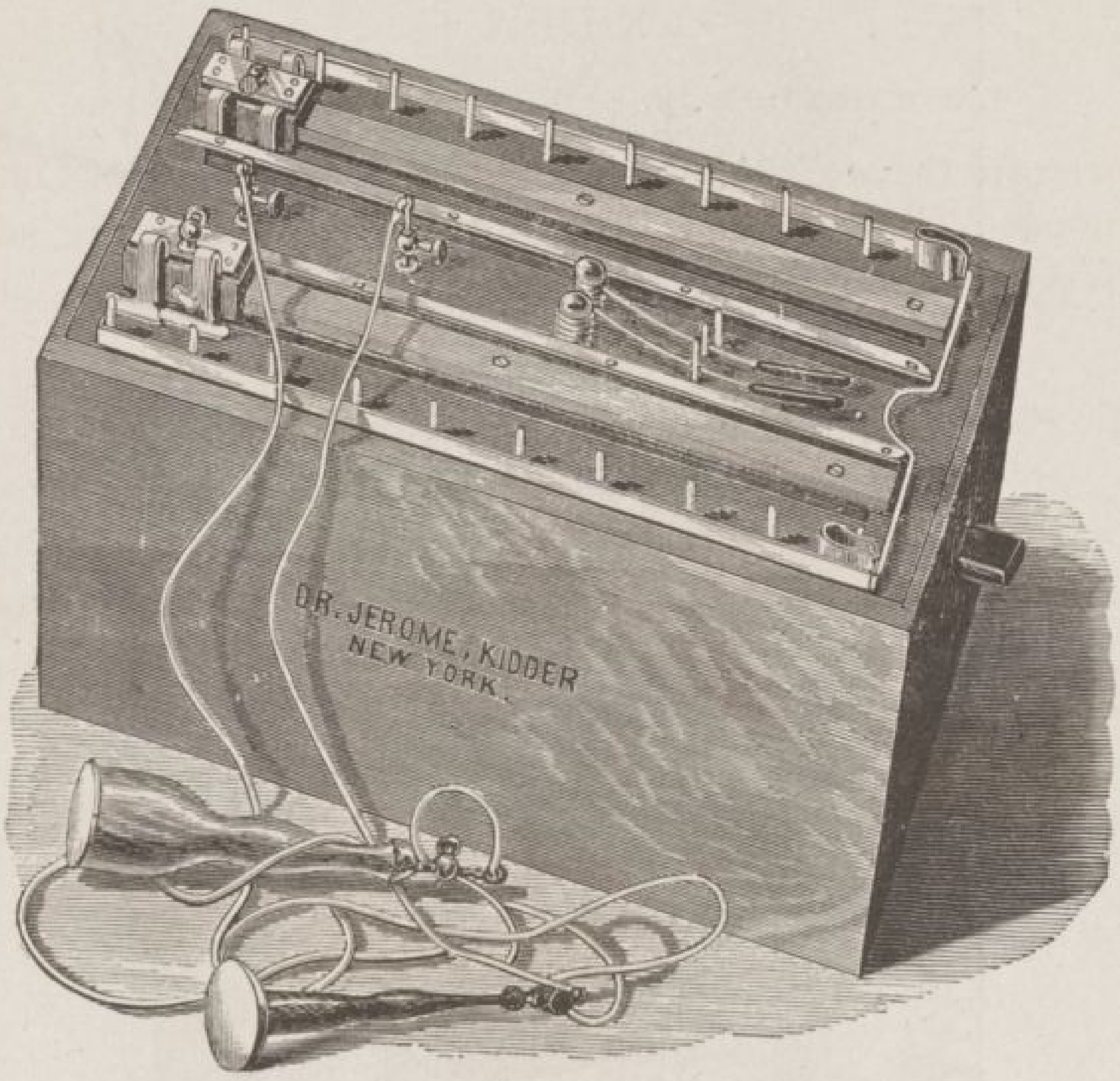
Mr. Flemming also exhibits certain batteries made in accordance with the general plan of his batteries, with the exception that the coils are more numerous, and are composed of various metals. By the varieties of the coils as to length, thickness of wire, and metals employed, it is claimed by the inventor (Mrs. French) that the batteries give rise to forms of current of essentially different physiological powers. The committee can see no reason to believe in the existence of such differences.



Mrs. French's Battery. (Flemming.)

THE KIDDER MANUFACTURING COMPANY, OF NEW YORK—GALVANIC APPARATUS.

The galvanic apparatus of these exhibitors consists of a sulphochromate battery (Battery A), and a large key-board for use with any desired form of cell.



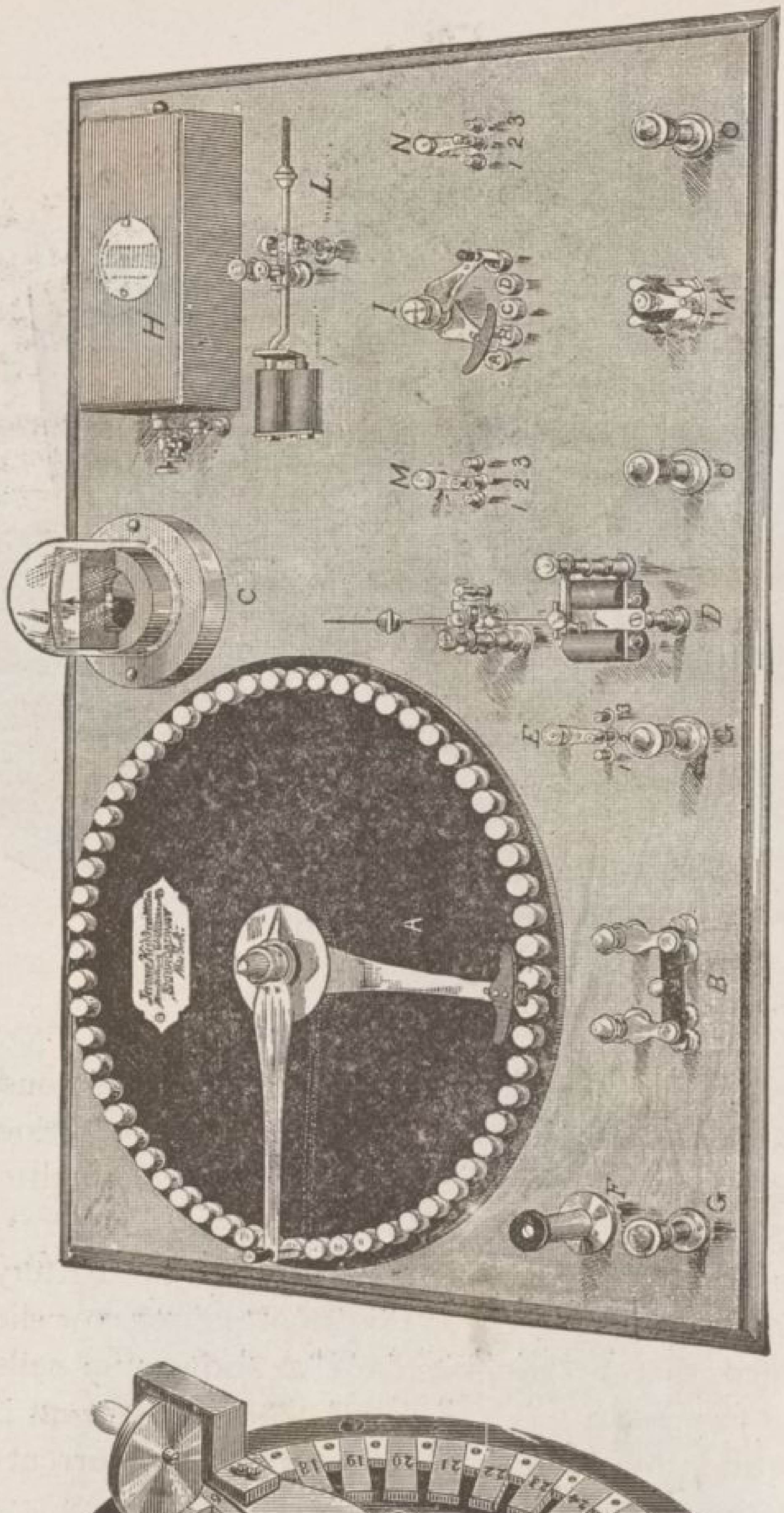
Battery A. (Kidder.)

Battery A is, in its elements and general form of construction, based on the well-known Stohrer battery. The objections to this form of battery have already been stated by the committee. (See Flemming's exhibit.)

There are certain arrangements of the present battery worthy of commendation. Especially is this so of the selector slide. This is so arranged that by hooking back a spring the cells can be added, so as to make a series of shocks when the current is rapidly increased; and, by loosening the spring, the current can be increased without shock.

This battery is excessively heavy, and as its glass cells are fragile and cannot be closed, it is not at all portable.

The key-board is adapted either to be placed on the wall or on a table. It is provided with separate commutators and separate terminal posts for the two currents, which duplication is not only unnecessary, but apt to give rise to annoyance. It is furnished with a galvanoscope and an automatic rheotome to interrupt the faradic current. This rheotome is not recommended because the


A
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C
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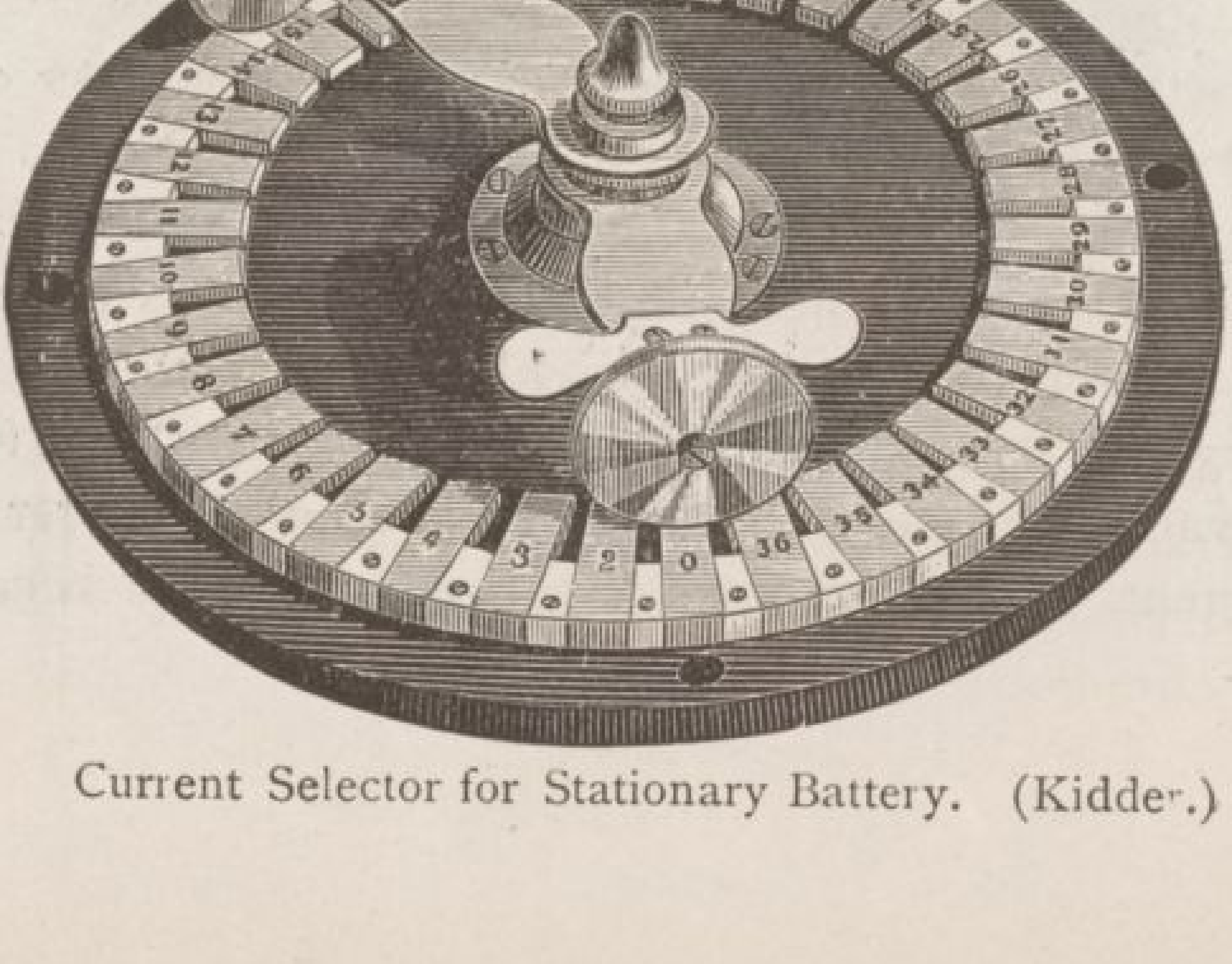
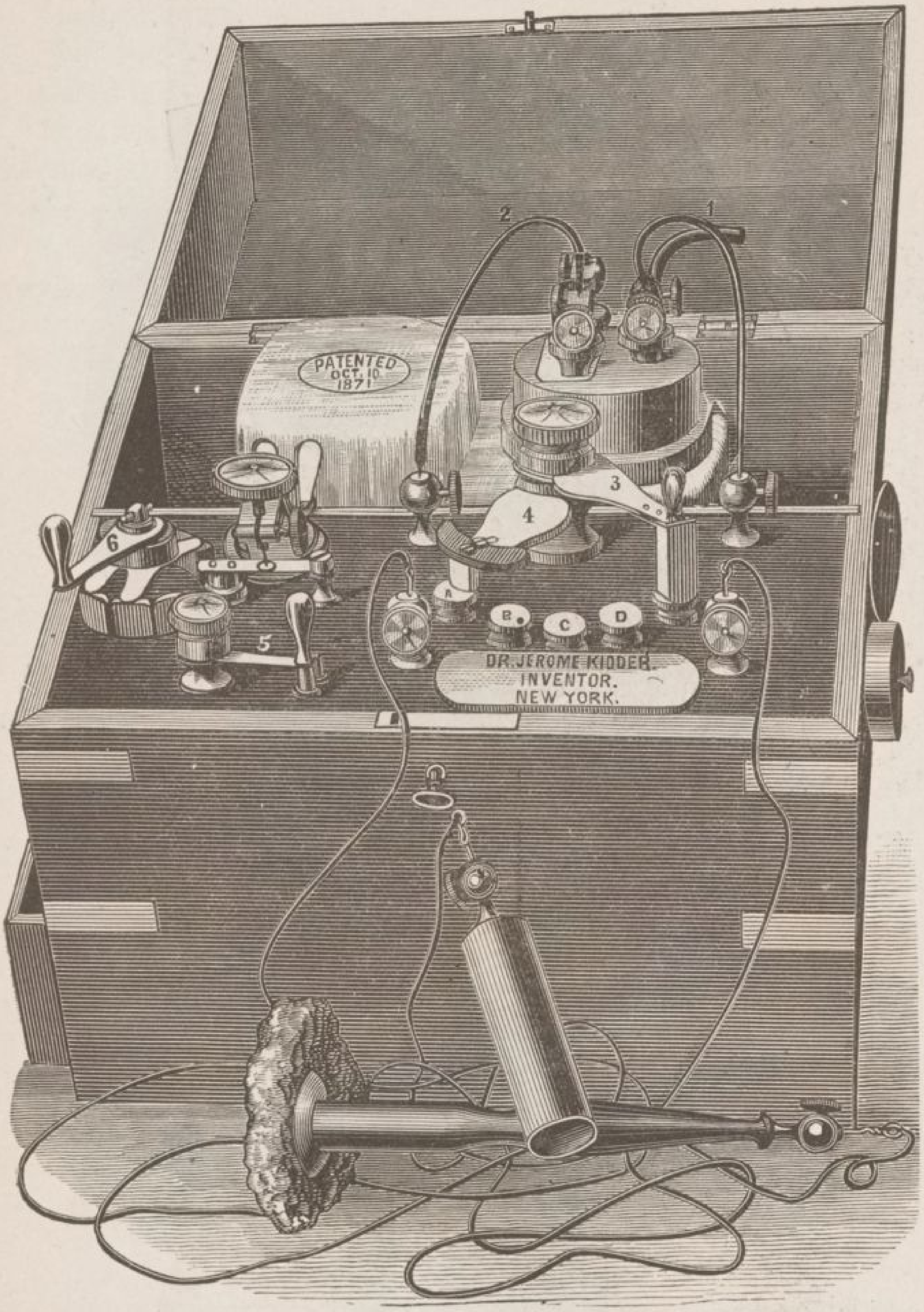
M 1 2 3
N 1 2 3

Stationary Key-board for any desired form of Cell. (Kidder.)



Current Selector for Stationary Battery. (Kidder.)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1
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1871
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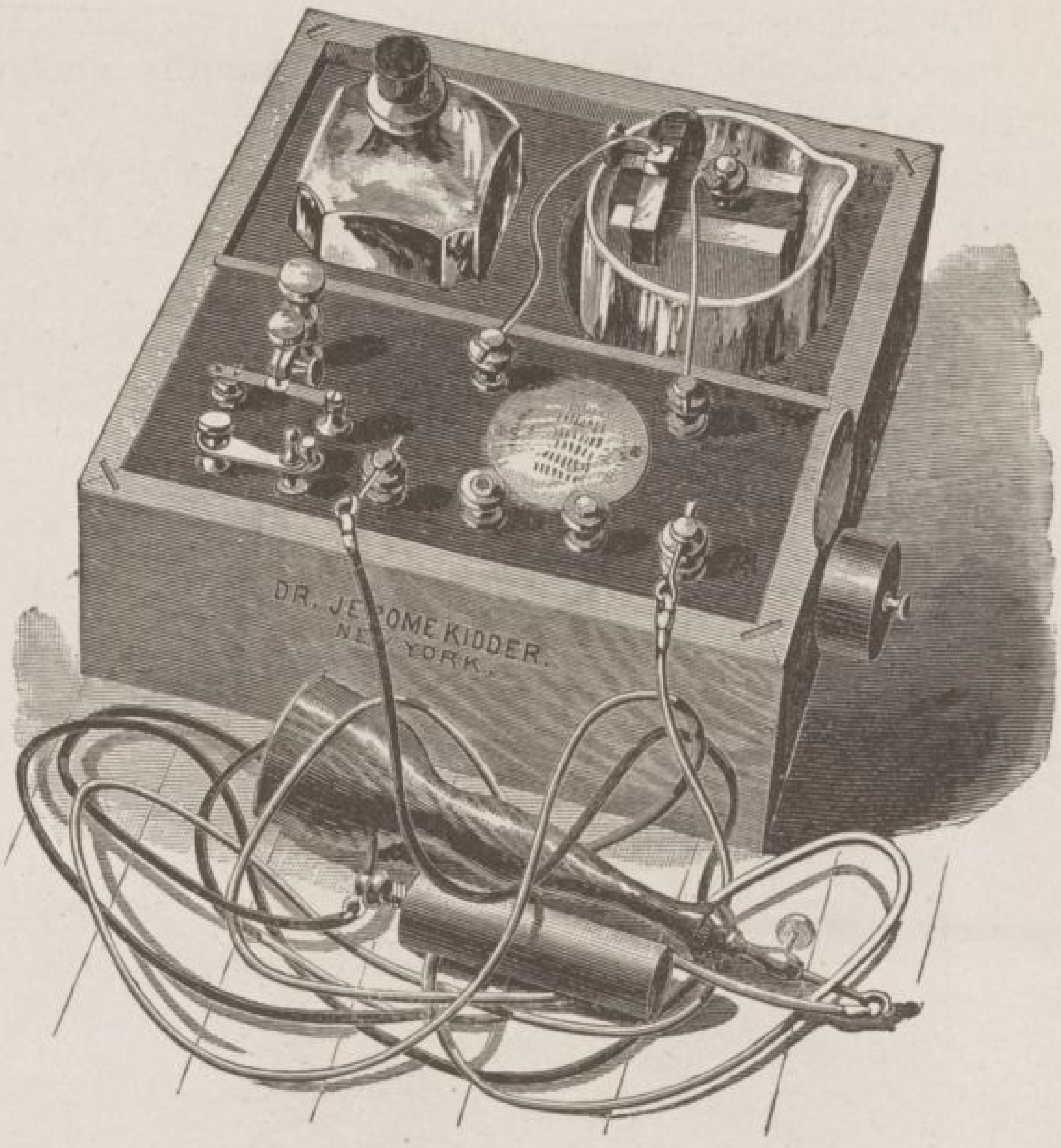
4
6
5
A
B
C
D
DR. JEROME KIDDER.
INVENTOR.
NEW YORK.

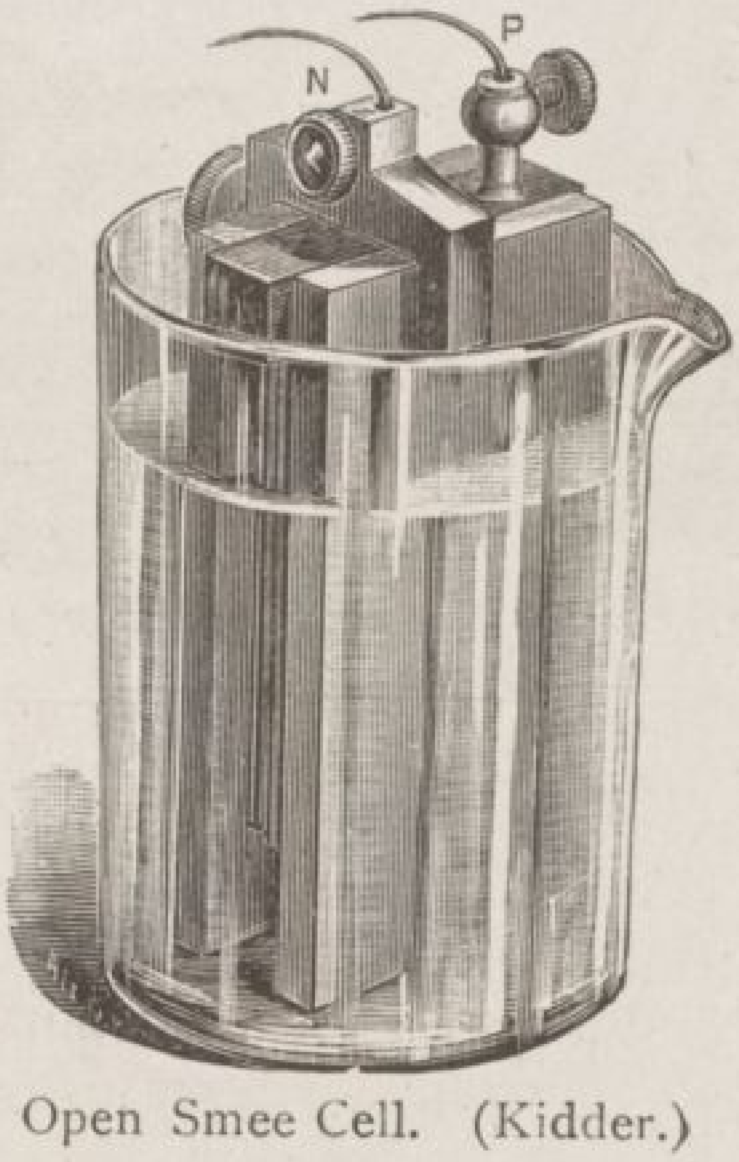
Large Faradic Apparatus. (Kidder.)

periods of current passage are very long while the interruptions are very brief. The commutator has the serious drawback that it cannot be used as a hand rheotome.

The arrangement for selecting the galvanic cells has the decided advantage of permitting a broken element to be thrown out of the circuit.


DR. JEROME KIDDER.
NEW YORK.

Faradic Battery with open Cell. (Kidder.)



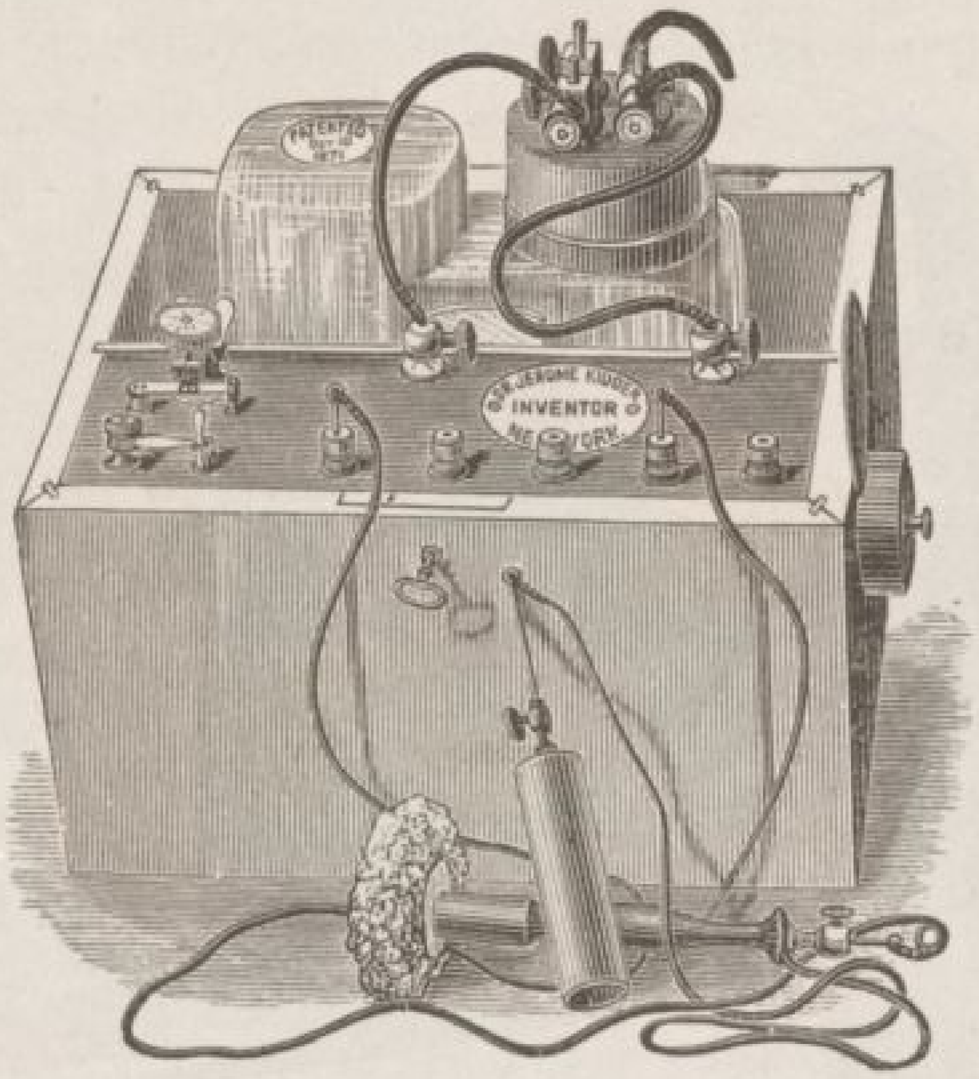
Open Smee Cell. (Kidder.)

There is no galvanometer.

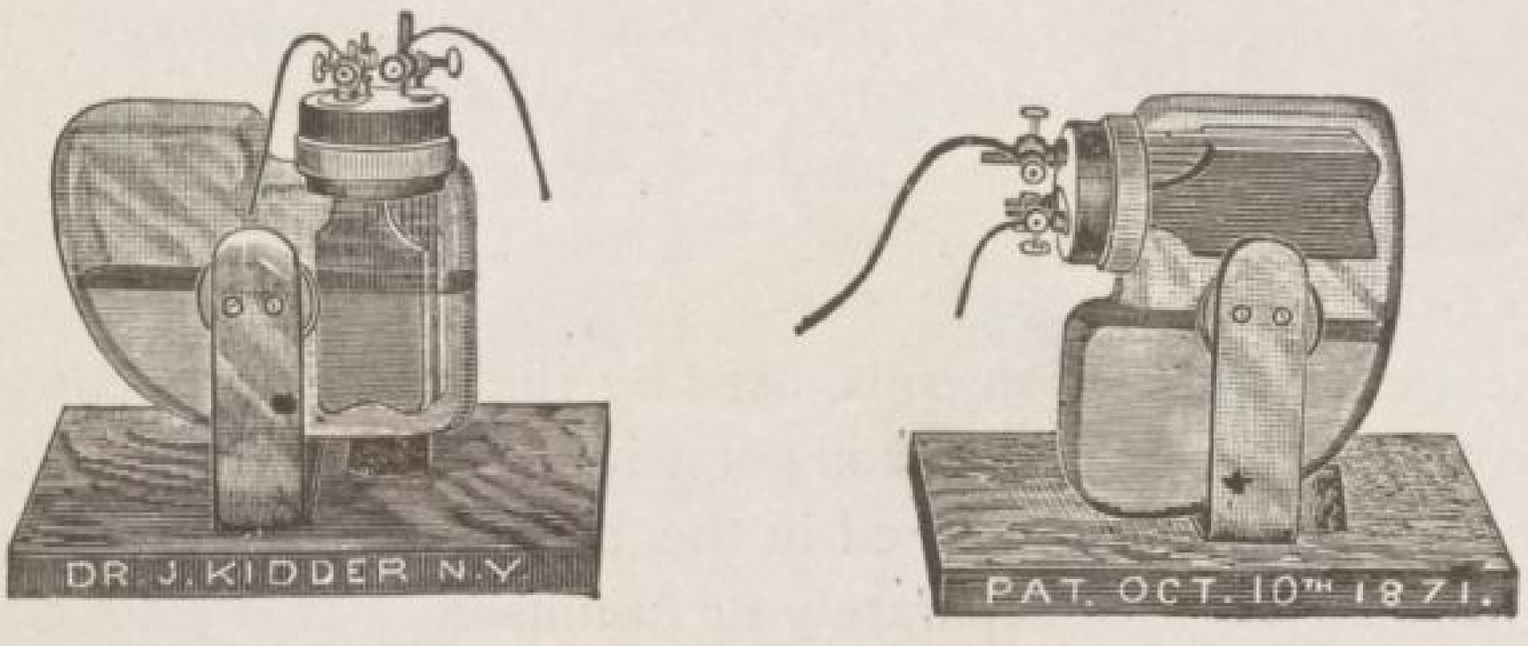
The key-board also contains a faradic apparatus similar to that used in Battery No. 2.

The rheotomes, which are two in number, are of good character, the slowest vibration attained by the exhibitor before the committee was sixty per minute.

Six forms of faradic battery were shown by these makers, varying only in size and strength. They are so entirely wanting in any form of slow interrupter that in the opinion of the committee they are not adapted to the practical work of the physician.



Faradic Battery with Tip Cell. (Kidder.)

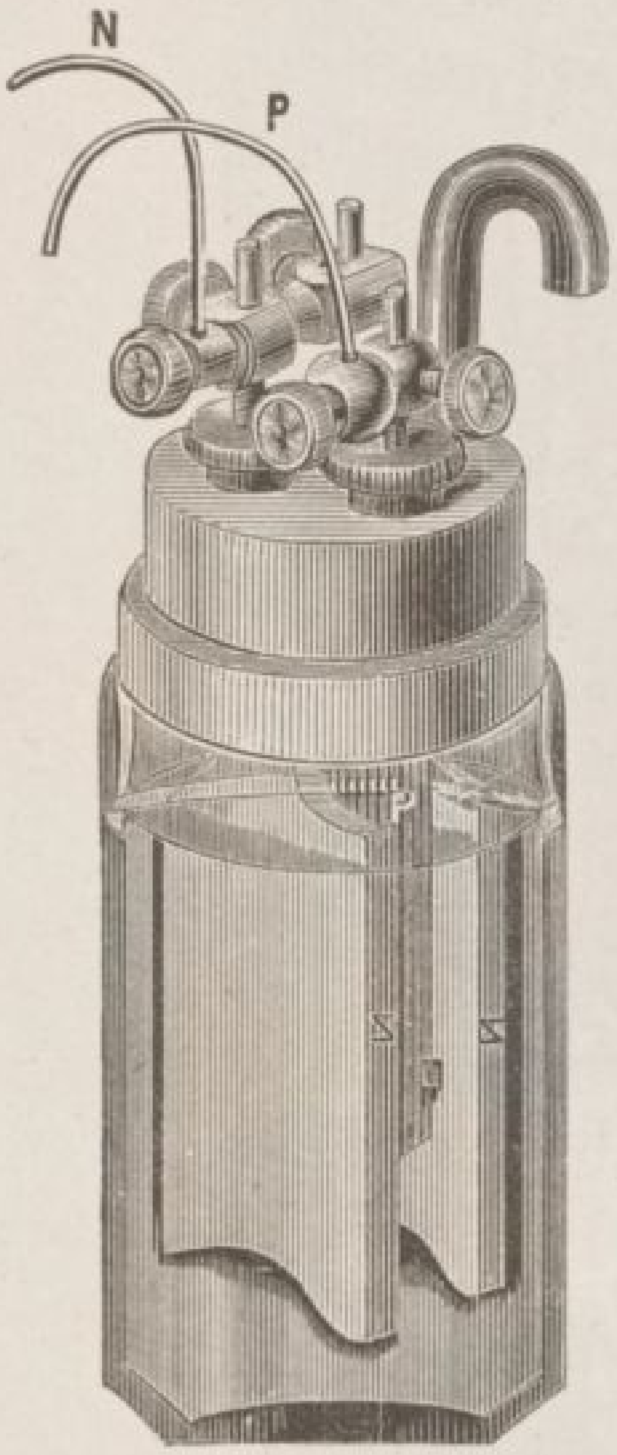

DR. J. KIDDER N.Y.
PAT. OCT. 10TH 1871.

Hydrostatic Tip Cell. (Kidder.)

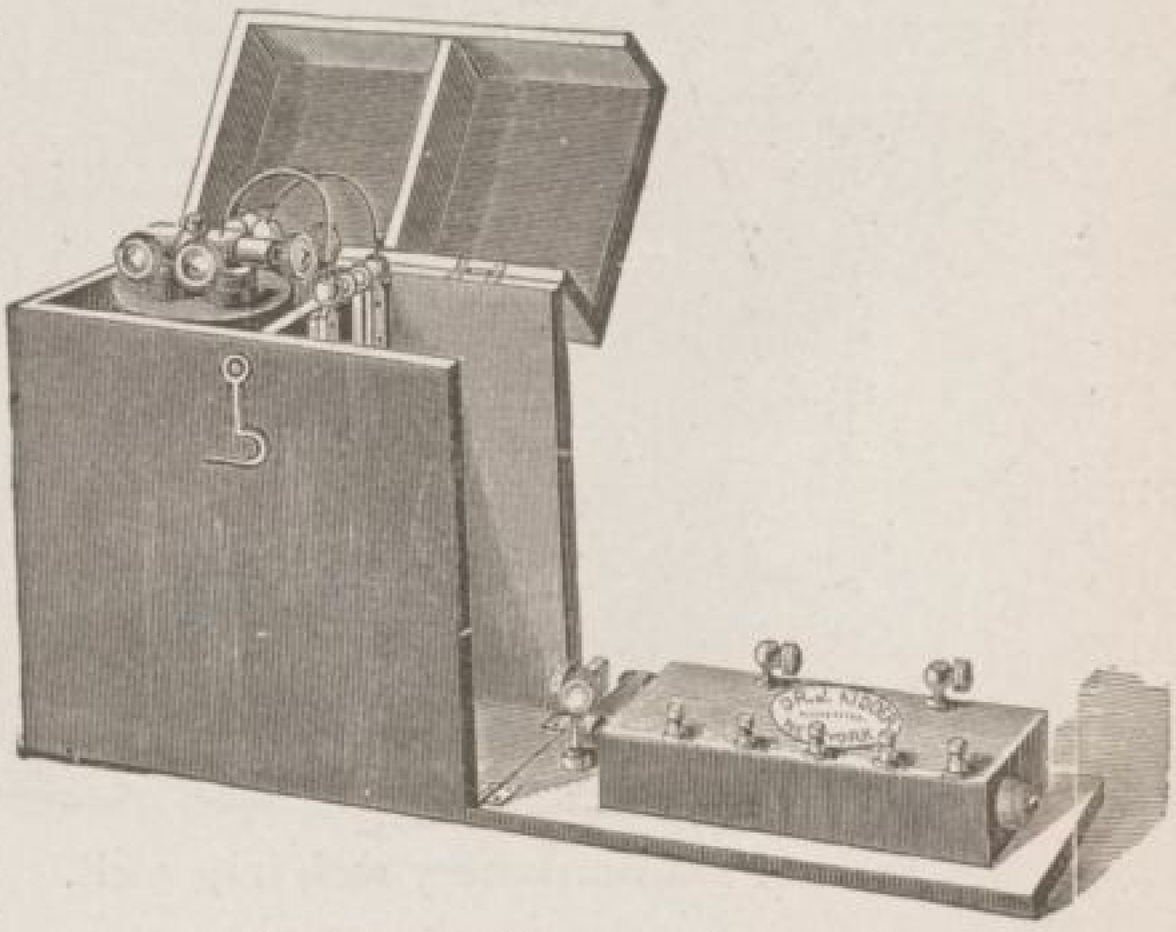
The cell employed is a modified Smee element. In all, except No. 1 and No. 5, the cells are left entirely open and require emptying of their contents before carriage, or else they are only partially closed. Such an arrangement of elements is intolerable.

Batteries No. 1 and No. 5 are provided with so-called hydrostatic tip cells which, though large and cumbrous, are sufficiently tight; and when not in use, the elements are exposed only to the vapors and splashings of the acid.

The Smee element is employed in all these batteries. Whilst this is more permanent than the sulpho-chromate cell, the greater electro-motive force of the latter, we believe, recommends it especially for use in portable faradic batteries.



Smee Cell. (Kidder.)



Physician's Visiting Apparatus. (Kidder.)

The general induction coils, used by the Kidder Company, are composed of three or more coils of wire, each differing in length and diameter, which are joined in the binding posts in such a way that they can be used separately or in unison. It is claimed that from the large No. 1 battery with four coils, ten galvanic currents of different physiological power can be obtained.

The following, in their own words, is a description of the points of superiority claimed for their coils by the Kidder Manufacturing Company.

"We have first the primary coil, over which the influence from the battery travels, operating the automatic circuit-breaker (rheotome), and producing a current of great quantity. Wound over the primary and thoroughly insulated is a coil having a greater length and smaller diameter than the primary coil and producing a current of greater intensity and less quantity than the current from the first coil.

"Over the first coil is wound a third coil, having a still greater length than the first and a small diameter, producing a current of still greater intensity than the second coil and of less quantity.

"In the ten-current apparatus we find a fourth coil over the third and the diameter of the wire is very small, while the length is greater than the total of the other three coils combined, producing a current of great intensity and adapted in quality for the relief of pain, etc.

"While the helix or coil is composed of various coils, they can be united so as to form one continuous coil, producing a great variety of qualities for the cure of diseases. The coils are so arranged, according to length and diameters of the wire, as to produce the best results with the battery-power that operates them.

"The influence of the primary coil or the quantity current from the battery can be conducted through the various coils of fine wire, or cut out of the circuit, so as to get the absolute induced currents from the induced coils when desired."

The general coil, in short, is composed of a series of coils, one within the other, all so arranged that they are or can be metallically connected from what is called a "continuous coil" machine. The innermost coil is short and made of thick wire; the next is longer and finer; the third is still longer and finer, and so on to the end of the series.

The number of coils used in the construction of the main coil varies with the size and price of the particular machine; thus one form of apparatus has two coils, another three and another four.

It is claimed that the different parts of this compound, continuous coil, can be so arranged and combined and so tapped, or drawn off for use as to give a large number of different currents or different variations of the qualities of the currents. It is claimed also that these different currents or different qualities of currents, produce different physiological effects, and different effects in the cure of diseases.

Great confusion and misapprehension may arise from the exhibitor's method of speaking of the currents in their various publications, as furnished to the committee. The first current derived from the primary coil is spoken of as "the primary influence," or "primary current," or "galvanic current." The next, "the first induced," etc. The facts being that the current from the first coil (A B), is simply the extra current or primary induced current and the others secondary currents.

It is well known that no galvanic current efficient for any medical purpose can be derived from the single cell of a faradic battery, and that the induced currents derived from coils superimposed upon one another, vary only in tension. All that can be said of this arrangement, is that certain induced currents of varying tension are obtained by the sub-divisions of the coil used. These currents undoubtedly vary in tension, but we were not able to obtain any clear evidence that these currents varied in their practical therapeutic effects.

The coil is one which is well adapted for all the therapeutic purposes for which faradic batteries are commonly used. The current or currents derived from it can be admirably regulated by the arrangement of the binding posts and regulator. The coil has no special disadvantages. What the committee objects to are the excessive claims of these exhibitors.

MR. FLIESCHMAN'S EXHIBIT.

The committee examined one continuous battery of this maker. It was made upon the general principles of the Stohrer battery, and is open to all the objections urged against this form. The mechanism appeared to be good, and we especially commend the simple arrangement by which a defective cell can be thrown out of the circuit and the current be increased cell by cell without shock.

The so-called large double cell pendulum battery is the chief faradic exhibit of Mr. Fleischman. The following claims are made for it by the exhibitor. A very regular and grateful current; the use of the pendulum interrupter, which requires very little power to keep in regular motion, when at rest is nearest the magnetic pole, has no loose connections, and that the coils are so arranged that there is a galvanic current in the primary current circuit.

The committee here reiterates what it has already said, that no efficient galvanic current can be derived from a single cell.

This battery certainly furnishes currents of very great power, but it appears to the committee to be lacking in delicacy, as is required in some departments of electro-therapeutics.

The sulpho-chromate galvanic element used is closed simply by an india-rubber cork, which is not retained by any mechanism, and is in our opinion liable to displacement. This greatly endangers the battery from the escape of corrosive fluid during transportation.

The so-called pendulum interrupter or rheotome is considered very worthy of commendation. It has the great advantage of having no joints to get out of order, and vibrates very steadily. The slowest vibrations claimed by the exhibitor before the committee were 112 per minute.

EXHIBIT OF MR. A. PARTZ.

The medical exhibit of Mr. Partz consists of a portable medical voltaic battery, which is described by the exhibitor as follows: It consists of fifteen tightly closed elements, 1⅝ inches square and 4½ inches high, applicable either together or in sets of three, six, nine and twelve, and contained in a box 6 inches high, 6 inches wide and 11¾ inches long, the whole weighing fourteen pounds. The electrodes are rods of zinc and carbon, the latter having been subjected to a peculiar chemical treatment having the effect of retarding polarization. The excitant liquid consists of a compound solution of about fifteen parts of chloride of zinc, and twenty-five parts of bichromate of ammonium in 100 parts of water.

For this battery, the following claims are made: The initial electro-motive force, as determined by Mr. A. Gaiffe, for one element is 1·65 volts; and after partial polarization through shunting, Count du Moncel and M. Hospitalier found its force to be 1·45 volts. (*La Lumière Electrique*, t. III, p. 168.)

The battery contains no acid, is free from all "local action," and may be kept in daily use for over a year without anything being done to it, provided that it be not unnecessarily exhausted by "short-circuiting;" that is to say, by placing the poles in contact without a part of the human body being inserted in the circuit.

In order to arrive at a positive conclusion concerning this battery, it was referred to the Battery Committee, which reports as follows:

Cell No. 1, E. M. F., 1·22 volts; internal resistance, ·8 ohm; current strength at setting up, ·42 ampères; after two minutes, ·39; after four minutes, ·39; after six minutes, ·27; after eight minutes, ·24. Cell No. 2, E. M. F., 1·6 volts; internal resistance, ·45 ohms.

Various galvanic belts were examined by the committee, but none of them have sufficient galvanic power to exert any influence even upon the human skin and certainly not upon the organs beneath it, and we believe that they can only do good by acting upon the imagination of the patient.

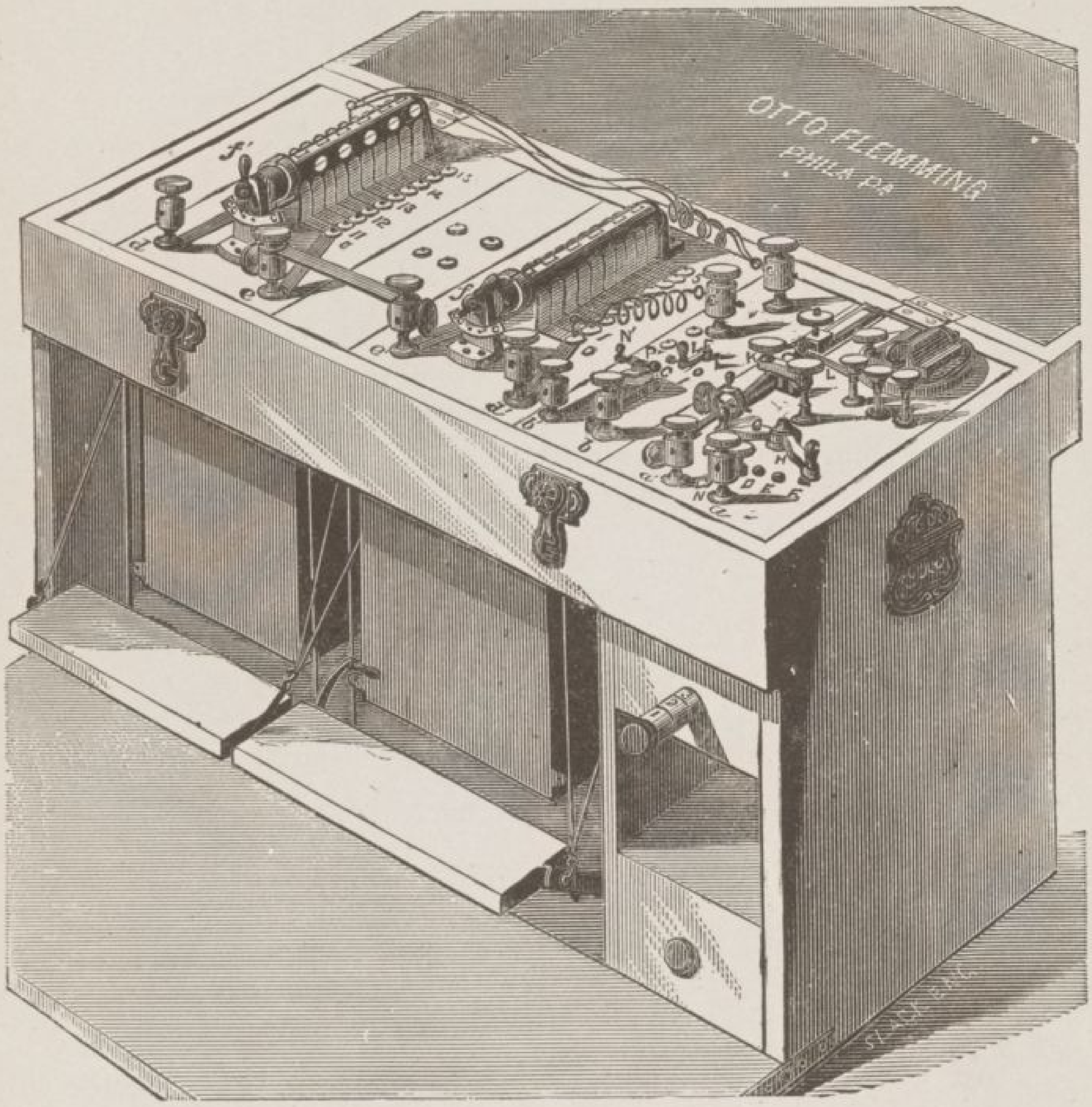
H. C. Wood, *Chairman*,
Chas. K. Mills,
Jas. Hendrie Lloyd,
G. Granville Faught,
Louis H. Spellier,
G. Betton Massey, *Secretary*.
Members of the Sub-Committee on Therapeutic, Galvanic and Faradic Apparatus.

CAUTERY BATTERIES.

The single Cautery battery, upon which the sub-committee will report, is the Universal battery of Mr. Otto Flemming.

The novelty of the movement, as Mr. Flemming states, consists of two systems of ten-zinc and of ten-carbon plates, each of which is suspended from two hard rubber platforms. A brass spring is connected to each plate by a screw, which passes through the platform and presses against a cylindrical commutator. In the lower portion of the box are placed two hard rubber cups, which are partitioned off into ten compartments each. Each cup contains a mixture of bichromate of potassium, sulphuric acid and water. The cups are placed directly beneath the system of suspended plates, and are immersed in the fluid when the treadle is depressed.

The advantages of the battery are pronounced. It can be managed without the assistance of an attendant. It is easily kept



Universal Battery. (Flemming.)

in efficient order, and seldom disappoints the expectations of the operator. The contact of the liquid with the zinc and carbon plates (being dependent upon the movement of the foot) determines both the degree of activity of the elements and the length of time they have been brought in contact.

Harrison Allen,
C. Seiler.

TK6
1884 m

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

REPORT OF EXAMINERS
OF
SECTION XXVI.

"APPLICATIONS OF ELECTRICITY TO ARTISTIC
EFFECTS AND ART PRODUCTIONS," WITH
WHICH IS INCORPORATED SECTION
XXV, "APPLICATIONS OF
ELECTRICITY TO MUSICAL APPARATUS."

8334

Philadelphia.

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

OF THE

FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

REPORTS OF THE EXAMINERS

OF

SECTION XXVI.

(*SECTION VII, OF THE CATALOGUE.*)

"Applications of Electricity to Artistic Effects and Art Productions," with which is Incorporated Section XXV, "Applications of Electricity to Musical Apparatus."

[ISSUED BY AUTHORITY OF THE BOARD OF MANAGERS AND PUBLISHED AS A
SUPPLEMENT TO THE JOURNAL OF THE FRANKLIN
INSTITUTE, MAY, 1886.]

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1886.

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EDITING COMMITTEE.

PERSIFOR FRAZER, *Chairman*,
CHARLES BULLOCK,
THEO. D. RAND,
COLEMAN SELLERS,
WILLIAM H. WAHL.

F.I. - June 1, 1904 - E.M.E.
S.S.C. Nov. 26/06

1884-INTERNATIONAL ELECTRICAL EXHIBITION-1884

FRANKLIN INSTITUTE, Philadelphia, Pa.

REPORT OF EXAMINERS.

SECTION XXVI.—APPLICATIONS OF ELECTRICITY TO ARTISTIC EFFECTS AND ART PRODUCTIONS.

To the Board of Managers of the FRANKLIN INSTITUTE:

GENTLEMEN:—I have the honor to transmit herewith the report of the Examiners of Section XXVI, on "Applications of Electricity to Artistic Effects and Art Productions."

Respectfully,
M. B. SNYDER,
Chairman Board of Examiners.

PHILADELPHIA, January, 1886.

PROF. M. B. SNYDER,
Chairman Board of Examiners, International Electrical Exhibition:

SIR:—The Examiners in Section XXVI, respectfully present the following report.

FRED. GRAFF,
Chairman Section XXVI.

PHILADELPHIA, January, 1886.

REPORT:

THE APPLICATIONS OF ELECTRICITY TO ARTISTIC EFFECTS AND ART PRODUCTIONS.

The Committee at its several meetings very quickly came to the conclusion that, owing to exhaustive sub-division of the labors of the Board of Examiners, very little original sphere of action remained for its consideration. Two subjects, and only two, appeared to call for report under its functions. (1.) The influence of electric lighting upon decorative taste. (2.) The application of electric lighting to photography.

I.

Whoever visited the exhibition at night, needs no reminder of the growing applications of electricity to the production of artistic effects. By its aid, the crude building, hurriedly erected without attempt at finish for a temporary purpose, was transformed into a temple of light, which at the first glimpse evoked expressions of delight from every beholder.

The exhibits of Edison and Weston were especially worthy of remark in foreshadowing the future general use of electricity in domestic decoration. Revolving stands laden with flowers, whose beautiful bright columns were disclosed by the electric lamps distributed amid their green foliage; purling fountains subsequently illuminated with various hues; glowing bouquets, all apparently usual features of a modern drawing room, gave a foretaste of the æsthetic furnishing of the future. It is evident that the general introduction of the electric light must have a most decided effect in the modification of everything that appeals to our taste. House decorations, dress materials, must all be fabricated with the condition of producing maximum pleasing effect under powerful and searching electrical illumination. The vista of possibilities of discussion opened from this point of view is illimitable, and the section has concluded—wisely it is hoped—to refrain from entering it. A probable reflex result may, however, be mentioned.

Physicians agree that we suffer in our homes from want of sunlight. We furnish, dress, and live for gaslight. When our surrounding shall have been accommodated to the brilliant illuminant of the future, we need no longer shut out the bright light of day, under whose health-giving sheen, dull eyes and waxen cheeks will brighten and bloom.

II.

Mr. W. Curtis Taylor, of Philadelphia, established an electrically lighted *atelier* in the Exhibition Building, and thus gave opportunity to thousands of practically witnessing the photography by electric light.

Owing to the circumstances of the case, he was necessarily cramped in room, yet notwithstanding this drawback. he was very successful in results. His method is fully described in the report herewith appended. Mr. Kurtz, of New York, exhibited some remarkably beautiful photographs taken by electric light. The Chairman and Secretary of the Section visited his studio in New York, and through his courtesy and that of his assistant, Dr. Ehrmann, were placed in full possession of the details of his method of procedure.

The apparatus employed by Mr. Kurtz, as will be seen by the description and wood-cuts given in Appendix B, is much more elaborate than that used by Mr. Taylor, requiring a skilful and artistic operator to manipulate the numerous lights and the movable posing platform.

Mr. Taylor's whole arrangement is exceedingly simple, can readily be erected and put in use in the usual photographic gallery. Its manipulation is comparatively easy, the cost of getting up the apparatus is low, compared with that as employed by Mr. Kurtz. It must, however, be conceded that the latter gentlemen has produced with his arrangement wonderfully artistic and perfect work, quite as good as many made by daylight.

Mr. C. H. James, of Philadelphia, exhibited some striking views of parts of the "Caverns of Luray," taken by electric arc lights, in 1882. The details of the method of doing this difficult work are contained in Appendix C.

FRED. GRAFF, *Chairman.*
O. E. MICHAELIS, *Secretary Section XXVI.*

APPENDIX A.

1328 Chestnut Street, Philadelphia.

Fred'k Graff, Esq., *Chairman, etc., Section XXVI, International Exhibition* Franklin Institute.

Dear Sir :—As an accompaniment to the collection of photographs, which I shall have the pleasure of presenting to the Franklin Institute, I beg to offer the following description of our studio in the Exhibition Building, where the negatives were made.

Since making the experimental photographs, in the hall of the Franklin Institute, in 1877 (believed to be the first made by electric light in America), I had not used artificial light for making negatives until my present arrangement was put into operation at your Exhibition.

Methods elsewhere adopted for photographing from life by electric light may be classed under two principal heads: (1.) The use of one or two powerful lights in conjunction with condensing reflectors of moderate size, and (2) the use of a large number of moderate lights without condensation.

In the first, it is sought to avoid the hard effects by making either the lamps or the sitter change position constantly during the operation, in order to round off the shades and produce modulation of the features. The former is the method of Liebert in Paris and Van der Weyde in London. I am able to lend for your inspection photographs by Liebert, taken at the Paris Exhibition, in 1881; and you have, in your own Exhibition, specimens of the work of Van der Weyde. I think you will agree that in each of these is a too definite line of demarcation between the lights and shades.

Mr. Kurtz, of New York, makes his sitter and camera box revolve together under a fixed light. He also has specimens in your Exhibition. Being a skilful and pains-taking artist, Mr. Kurtz has produced excellent effects by this means, where the mere photographer would have made a miserable failure. As a strong objection, however, to his method, I submit that most sitters would find it very inconvenient to be swinging about; as at such a time they find it hard enough to keep tranquil even under the most favorable circumstances.

Mr. Mayall's light in London, is on the principle classed above as second. He uses a great number of Swan's incandescent lamps, arranged in circles over and around the sitter, but so far as my latest information goes, no general diffusion or softening of the light is otherwise attempted. It cannot be agreeable to the eye. I have seen no specimens of his work.

It was my object, when preparing for the present Exhibition, to imitate as closely as possible the natural daylight effects of our permanent studios, the result of long and general experience of photographic needs. The problem, then, was to produce a flood of gentle, but sufficient, white light, to cover such an area at the top and one side as should throw over and around the subject, from this *one* source, a light of its own nature diffused and requiring no counter lights for its modification. This is precisely what we do in our skylights. To effect the same purpose at the Exhibition we placed two arc lights of 1,000 candles each near the central line of the studio, 4 feet apart, and about 8 feet 6 inches from the floor. The light nearly overhead to the sitter is covered with a porcelain globe; the other with a glass globe, ground on the lower

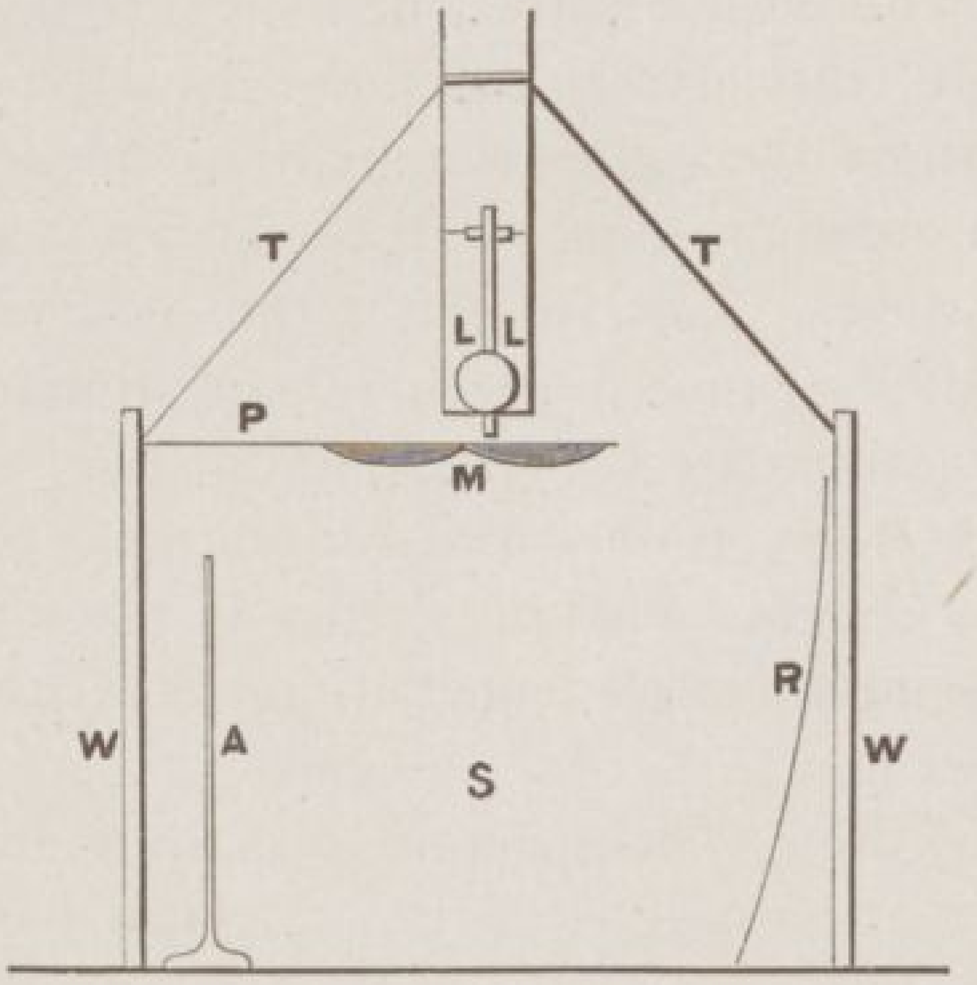

FIG. 1.—Section of Studio at International Exhibition of FRANKLIN INSTITUTE. Plan by W. Curtis Taylor. 1884.

W W.—Side walls of studio.
L L.—Arc lamps arranged parallel with sides of room.
T.—Tent.
P.—Tissue paper to diffuse light.
R.—White drapery, adjustable ; for reflection.
A.—Dark screen, adjustable; for absorption of light.
S.—Usual position of head of sitter.
M.—White muslin, to subdue too intense light over sitter's head.

half and clear above. Covering these was a white muslin tent, the whole size of the apartment (which was 10 x 12 feet) and rising at the apex about 4 feet above the lamps. Spread on wires below the lamps was a sheet of silicated tissue paper, nearly the size of thetop of the room, and about eight feet above the floor. This served the double purpose of further diffusing the great body of light shed down from the lamps and the white tent, and of bringing the light nearer to the floor, thus increasing the angle of illumination. This paper stopped about 2 feet 6 inches short of that side of the room corresponding to the "side light" of an ordinary studio, in order to allow the unobstructed light to pass over it at that place. The free light from above here fell upon a white muslin reflector, hung on the wall, and reaching to the floor. The force of this reflector was varied by inclining it at a greater or less angle to the light rays. On the opposite side of the room a greater or less exposure of dark drapery determined the position and depth of shade required for artistic effect.

From what is here stated, it will be seen that the prominent and peculiar feature of this plan is the simplicity of its means for producing around the subject a great extent of diffused and non-brilliant light. The common remark of all who saw it for the first time was that it was "softer than daylight," yet it was sufficient to make a perfect dry plate negative in six to twelve seconds.

On this, the closing day of the Exhibition, I will add, as the result of our experience, that nothing was needed to make our experimental light right as to principle but more space in our studio. There is a certain atmospheric effect, hard to be described, which it is impossible to get in a little cooped room.

Respectfully submitted,

W. Curtis Taylor,

October 11, 1884.

APPENDIX B.

Mr. Kurtz endeavors to secure as thorough diffusion of the light as possible by multiplying the number of arc lamps, and providing each with globes of ground oropaline glass, or with lanterns of thin tissue paper. The lights may also be grouped in various ways relatively to each other. But not satisfied with this, Mr. Kurtz resorts to the expedient of placing both the sitter and the camera on a platform pivoted on a centre pin, and of rotating the platform during the operation of photographing so as to vary the angle at which the light from each lamp strikes the sitter. In this way the light is made to strike each feature at every angle as it passes successively from a shady to a lighted position or vice-versa, and thus an artificial diffusion is obtained which produces superior blending effects in the lights and shadows of the picture.

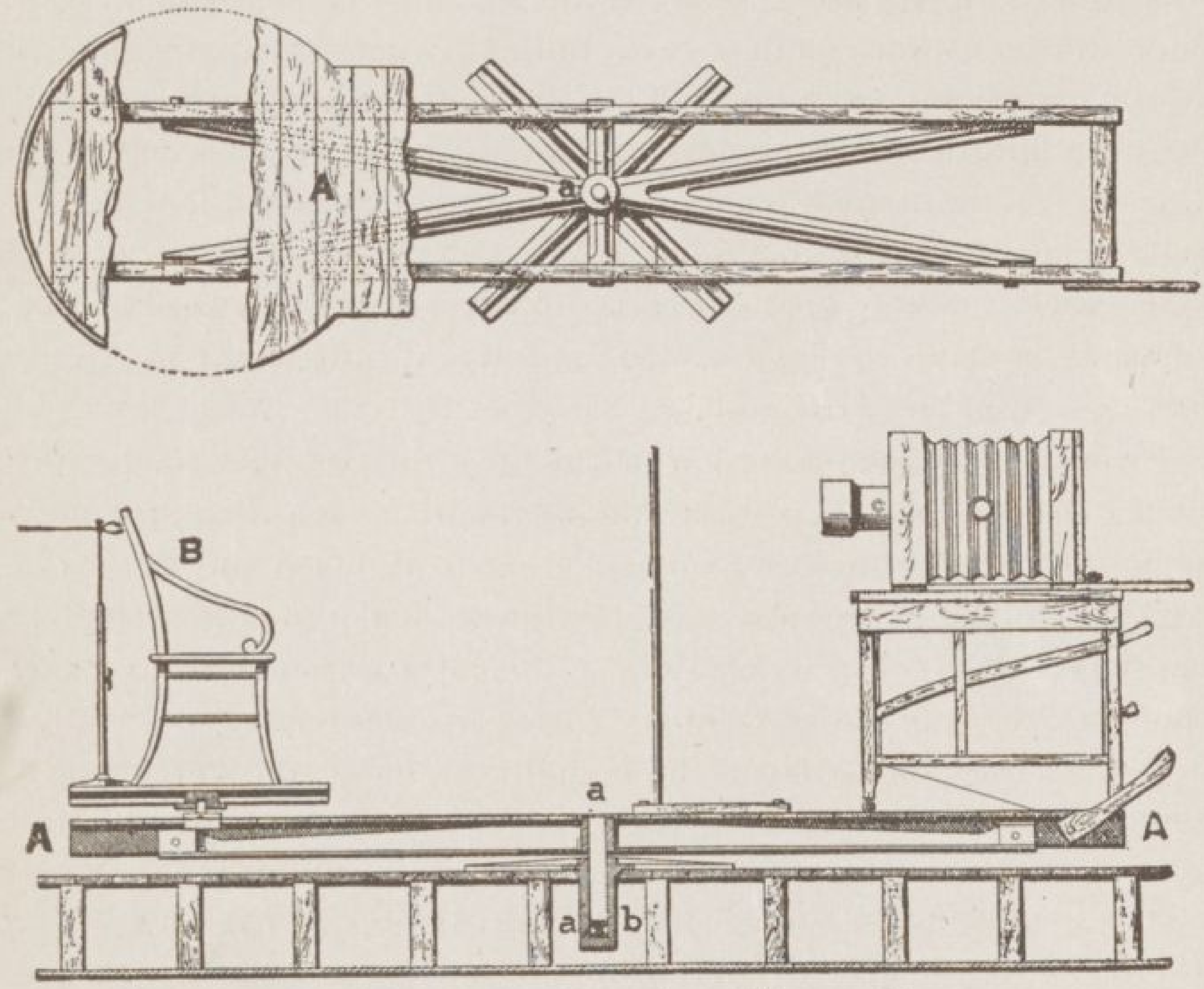

Fig. 2.—Plan and Section of Turn-table.

A.—Movable platform.
B.—Chair for sitter.
C.—Camera.
a b.—Pivot upon which the platform revolves.

The camera occupies one end and the sitter the other end of the platform, which is raised above the floor and turns on its centre on a steel pin which is received in a vertical bearing in the centre of the floor. The frame of the platform consists of two cross beams superposed at the centre, and supporting two parallel beams extending lengthwise and upon which the flooring is laid transversely.

This construction gives great solidity to the platform and diminishes the chances of vibration, whether lateral or longitudinal, by which the sitter and the camera might be disturbed relatively to each other, as the platform is rotated by the operator. This is important, for if the platform vibrated in this manner the image in the camera would be displaced to and fro to a slight extent, and the picture would be blurred and indistinct. A curved screen placed behind the sitter serves as a kind of concave reflector, which assists in diffusing the light from the lamps. The camera stand is supported on wheels, and it is movable on a small track (not shown in the engraving) from one side of the platform to the other in the arc of a circle of which the centre is exactly at the point occupied by the sitter. This innovation will greatly interest photographers, and it reflects credit on the ingenuity of Mr. Kurtz. The utility of this arrangement is very great. It is customary, at least in this country, to take several views of each sitter, in different presentations, such as full face, right side, left side, etc., and let the sitter select from the proofs of the negatives that which is the most suitable. In every case it is necessary to re-focus the camera with each change of position. But with this arrangement the camera remains in focus as it moves, and thus two or more positions may be photographed without trouble to the operator, who simply pushes the camera sidewise and exposes a fresh plate. The arrangement by which the operator is enabled to dispose the lamps at the convenient distance, and in the proper relation to the sitter, is most ingenious, and recalls the overhead railways found in machine shops where heavy pieces of machinery are to be moved from one machine to the other. The group is composed of six arc lights, which are suspended from a transverse frame extending horizontally from one side of the room to the other at a little distance below the ceiling, and which constitutes a travelling carriage, provided with wheels or rollers and moving on wooden rails extending from one end of the studio to the other on each side and supported by wooden brackets.

The transverse frame itself carries a smaller carriage which moves from one side of the room to the other, and supports the screen-holder, consisting of a horizontal frame which rotates on a vertical pin projecting down from the smaller carriage. To this frame, a flat screen is hung on couplings, so that it may be disposed at any angle, from the vertical to the horizontal. The larger or main travelling carriage supports three of the six arc lamps, and the screen-holding frame supports the remaining three. It will be seen that in this way the lights are in reality divided into two groups which can be moved together or singly. Thus, when the transverse frame is moved, the whole system moves, but when the smaller carriage is moved, from side to side, only three lights are moved, thereby establishing a new relative position between the two groups, which may be varied still further by swinging the screen-holder which supports them. Not satisfied, however, with the facilities for varied diffusive effects which this arrangement affords. Mr. Kurtz has provided each lamp with its own small travelling carriage, so that the lights of each group may be moved from side to side as occasion requires.

Mr. Kurtz has adopted the electric lighting system of the Excelsior Electric Company of this city.

The time of exposure is not greatly in excess of that required under an ordinary skylight. A cabinet size head taken with a 3 B Dallmeyer lens, using a No. 2 stop and on a plate of average capacity (Mr. Kurtz's own manufacture in most cases) requires five to eight seconds, although the time has been reduced to three seconds under special circumstances. For measurement, a metronome is used.

In the basement of the premises connected with the main establishment, there is a branch for the photographing of technical and other inanimate objects; for the reproduction of maps, prints, drawings, etc.; silver printing and the making of process plates—all being done by the electric light. Here was recently accomplished the photographing of the electric spark of the telephone in the $\frac{1}{24,000}$ part of a second.

APPENDIX C.

The negatives, from parts of the Caverns of Luray, of which photographs were exhibited, were taken in the year 1882, by Mr. C. H. James, of Philadelphia.

The pictures intended for the stereo, on 5 x 8 plates, were made with a pair of Dallmeyer's quick-acting four and one-half focus single view lenses; those on 7 x 9 plates, with an eight-inch focus Ross portable symmetrical lens, and the large 18 x 22 plates, with an eighteen-inch focus Ross portable symmetrical lens, almost all the pictures being taken with the smallest stop of the respective lenses. The exposures with the first named averaged two and one-half hours, the 7 x 9 three and one-half, and the 18 x 22 as much as eight hours.

The focussing was difficult, and accomplished by means of a lighted candle set upon such spots as it was desired to photograph.

The illumination by which the pictures were made, was supplied by the Thomson-Houston arc lights, with which all the most frequented parts of the cave are furnished. These are supplied from the dynamo in an engine house at the hotel, at a distance of nearly a mile from the cave, communication being kept up between the operator and the engineer by telephone.

The power of the light was estimated at 3,000 candles, and in all cases where the character of the subject required more than one of the lamps, the greatest care was taken in the management of the illumination, which was reënforced by the use of a screen or partial reflection of white paper immediately behind the lamp, so as to break up the light, modify and deprive it of its extreme harshness. Much of the success was attributed to the skilful use of this device. Indefatigable patience and hard work was required to obtain successful results.

Mr. James found the electric light exceedingly deceptive, for in many cases when but little or nothing could be seen upon the ground focussing glass of the camera, comparatively short exposures gave good negatives.

The pictures were all taken upon gelatine dry plates.

1884–INTERNATIONAL ELECTRICAL EXHIBITION–1884

FRANKLIN INSTITUTE, Philadelphia, Pa.

Report of Examiners of Section XXV, on the "Application of Electricity to Musical Instruments."

(Issued as a Supplement to Section XXVI.)

REPORT.

There was only one exhibit in this class, viz., the Roosevelt electric organ. Electricity is made to perform all the work of the "action." The "trackers," "rollers," "stickers" are dispensed with in the key action, and the various levers, etc., in the stop action, thus securing extreme simplicity, and consequently little liability to get out of order, and making it possible to place the key-board at any distance from the organ, and even move it from place to place if desired. The current is supplied by a Leclanché battery, and is utilized as follows: A row of electro-magnets, one for each key, is placed under the pneumatic valves that open the pallets. The armatures are attached to the pneumatic valves. When the key is depressed, the circuit is closed, causing the magnet to attract the armature, thus opening the pneumatic valve. When the circuit is broken, the pneumatic valve is closed instantly by a spring. The device for closing the circuit consists of the following parts: (1.) On the under-side of the key is a thin vertical strip of brass. (2.) A strip of wood passes horizontally across the keys, furnished with small brass buttons—two to each key—to which the wires from the battery are attached. When the key is depressed, the vertical strip of brass slides from the upper to the lower button, thus forming a metallic connection, and closing the circuit. A similar device is applied to the draw stops, pedals, combinations and couplers.

H. A. CLARKE,
Chairman of Committee.
RICH. ZEIKWER.

sec. 6, 10, 11, 18, 21-23,
26, 29.

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1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

REPORT OF EXAMINERS
OF
SECTION XXIX

"Educational Apparatus," with which is Incorporated Section XIII, "Apparatus for High Electro-Motive Force."

8334

Philadelphia.

1884—INTERNATIONAL ELECTRICAL EXHIBITION—1884

OF THE

FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

REPORTS OF THE EXAMINERS

OF

SECTION XXIX.

(*SECTION VIII, CLASS I OF THE CATALOGUE.*)

"Educational Apparatus," with which is Incorporated Section XIII, "Apparatus for High Electro-Motive Force."

[ISSUED BY AUTHORITY OF THE BOARD OF MANAGERS AND PUBLISHED AS A SUPPLEMENT TO THE JOURNAL OF THE FRANKLIN INSTITUTE, MARCH, 1886.]

PHILADELPHIA:
THE FRANKLIN INSTITUTE.
1886.

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1884 m

EDITING COMMITTEE.

PERSIFOR FRAZER, *Chairman*,
CHARLES BULLOCK,
THEO. D. RAND,
COLEMAN SELLERS,
WILLIAM H. WAHL.

T.C. – June 1, 1904 – G.W.C.
S.G.B. Nov. 2 '06

1884–INTERNATIONAL ELECTRICAL EXHIBITION–1884

FRANKLIN INSTITUTE, Philadelphia, Pa.

REPORT OF EXAMINERS.

SECTION XXIX.—EDUCATIONAL APPARATUS.
SECTION XIII.—APPARATUS FOR HIGH ELECTRO-MOTIVE FORCE.

To the Board of Managers of the FRANKLIN INSTITUTE:

GENTLEMEN:—I have the honor to transmit herewith the report of Examiners of Sections XXIX and XIII, on "Educational Apparatus," and "Apparatus for High Electro-Motive Force."

Respectfully,
M. B. SNYDER,
Chairman Board of Examiners.

PHILADELPHIA, February, 1886.

Chairman Board of Examiners, International Electrical Exhibition:

SIR:—I herewith hand you the report of Section XXIX, on "Educational Apparatus."

Respectfully,
A. E. DOLBEAR,
Chairman Section XXIX.

Chairman Board of Examiners, International Electrical Exhibition:

SIR:—I herewith hand you the report of Section XIII, on "Apparatus for High Electro-Motive Force."

Respectfully,
J. B. DEMOTTE.
Chairman Section XIII

GREENCASTLE, IND., December, 1885.

REPORT ON EDUCATIONAL APPARATUS.

EXHIBIT OF JAMES W. QUEEN & CO.

The general exhibit of this company was of much greater variety than that of any other exhibitor, and embraced useful devices for illustration and demonstration in nearly the whole field of physics.

The attention of the committee was directed chiefly to the specific electrical apparatus useful for educational purposes, as distinguished from instruments of precision; which latter department was in the hands of another committee. A very large part of experimental philosophy is quite independent of the question "How much?" and in the dominion of electricity it is particularly the case that the phenomena may be developed, and the relations studied without any attempt towards quantitative results.

Messrs. Queen & Co. were instrumental in securing a large number of foreign exhibitors, whose apparatus was shown in the space allotted to them.

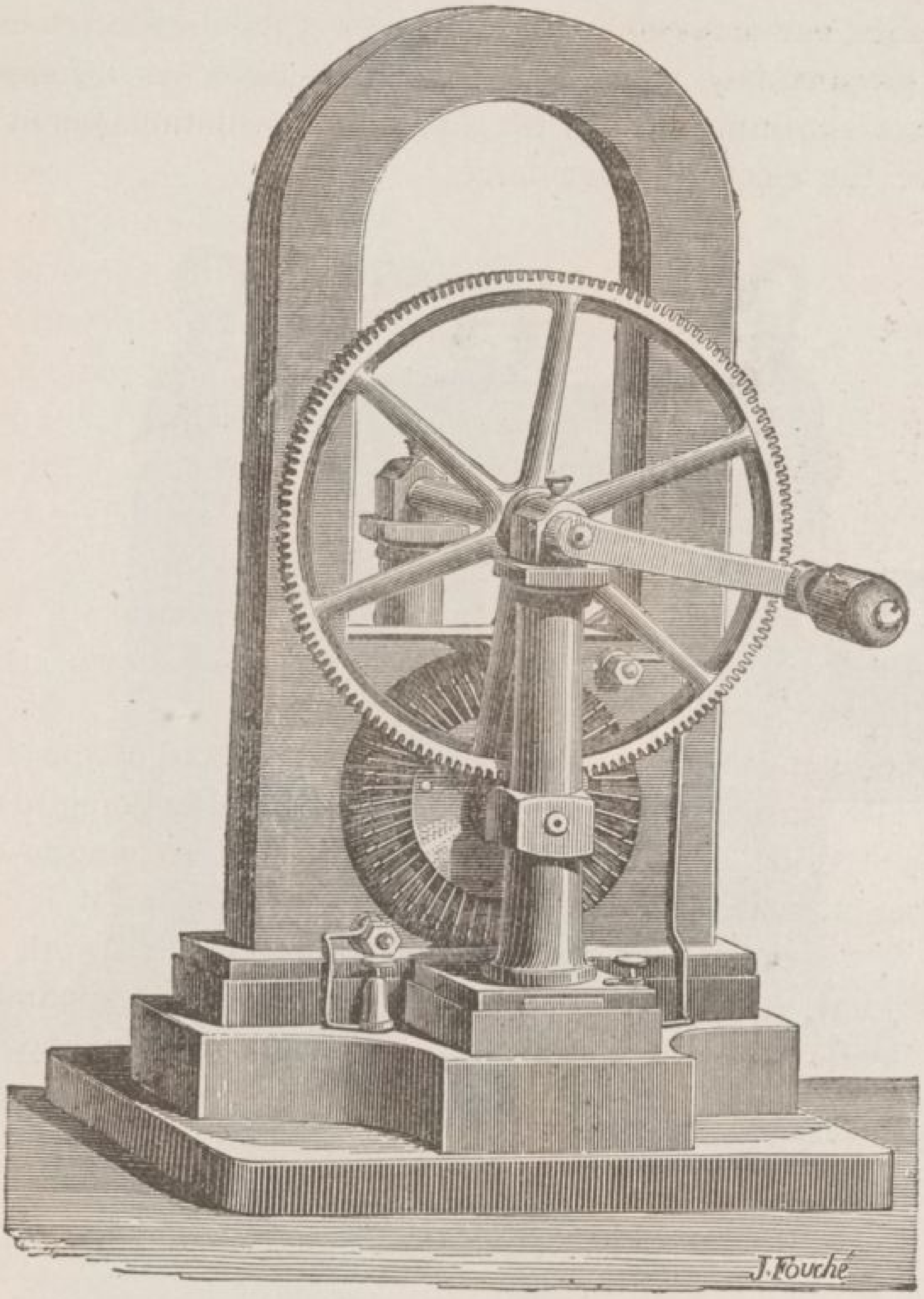
A part of many of these separate exhibits consisted of apparatus properly called instruments of precision, and referably going to that examining section. Because in many institutions of learning to-day, measuremental work of the highest grade is done, and it is difficult to draw a line between instruments adapted to such work and what is ordinarily understood by the term Educational Apparatus; and on the other hand, the skilful teacher is able to do some very fair quantitative work with instruments designed only for indications.

It has been thought best to incorporate into this report the special reports on hand dynamos, by Prof. W. A. Anthony, of Cornell University, and by Lieut. Murdock, U. S. A.

Queen & Co.'s Exhibition Catalogue contained upward of 1,600 numbers. The committee could not inspect them all but everything they specifically looked for, they found. The following they deemed worthy of special mention.

EDUCATIONAL APPARATUS BY BREGUET.

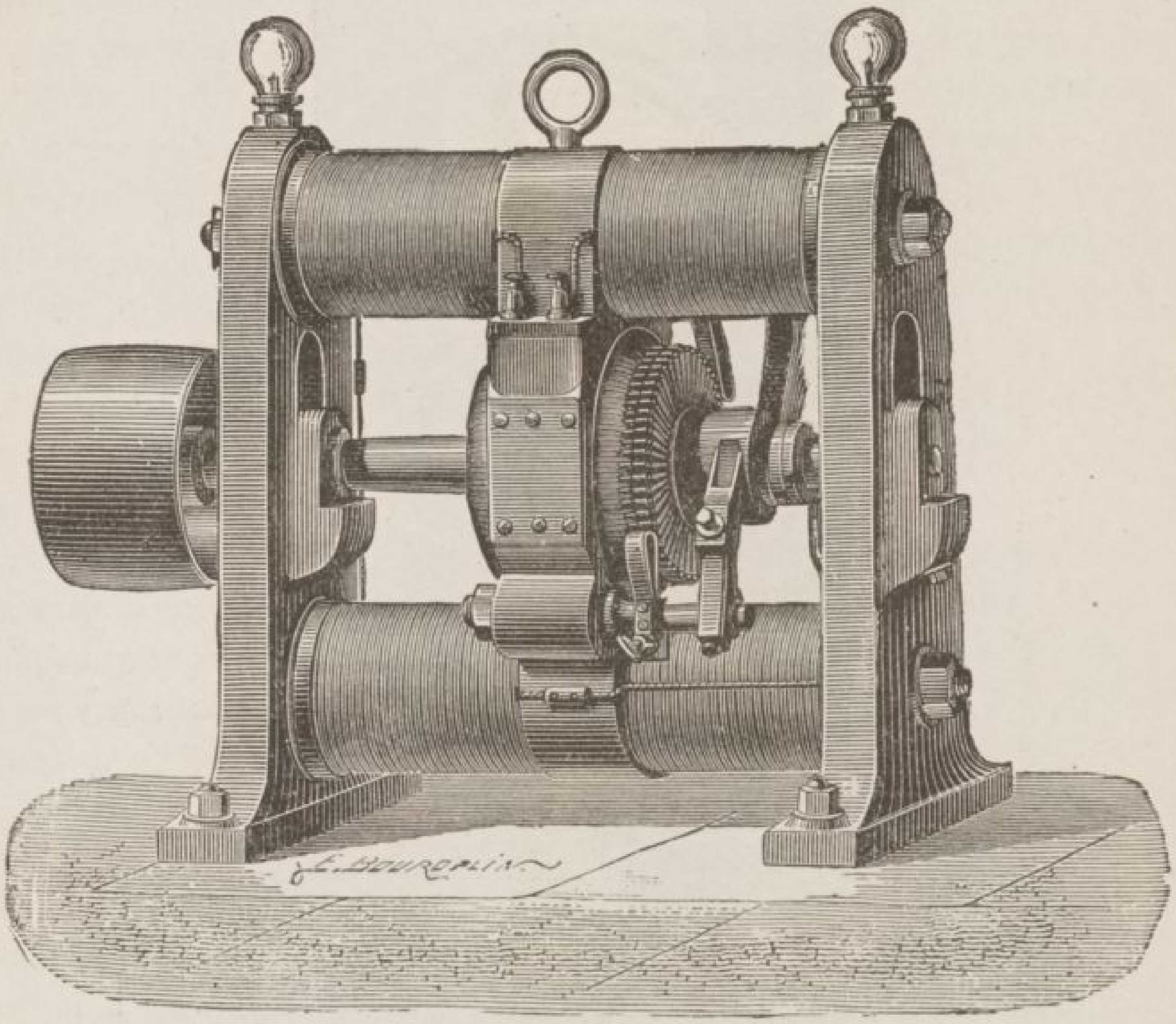
Gramme Machines.—The structure and principles of the Gramme machine are so well known that a description of them is not thought to be necessary here. They are compact, exceedingly simple in structure, easily managed, and very efficient. A number of these of different sizes, and adapted to be run by hand or by the steam engine, were exhibited. The smaller ones to be run by hand



No. 16. Gramme Magneto-Electric Machine.

are provided with powerful permanent magnets to furnish the magnetic field, and such ones may be used as substitutes for a small galvanic battery, and a large number of experiments may be performed with the current from such a machine. The machine may have armatures wound with coarse or fine wire, or what is better, have both. One may then have a high electro-motive force, or a low electro-motive force, adapted to his needs. With the machine made for laboratory model and with thick wire armature, one may produce about ten volts and two and one-half ampères current with a speed of 2,640 revolutions per minute.

With the fine wire armature, one may have about forty volts at the brushes, and a current of five ampères As the electro-motive force is proportioned to the speed, each machine has a numerical constant which, multiplied by the number of revolutions per minute, will give the electro-motive force.

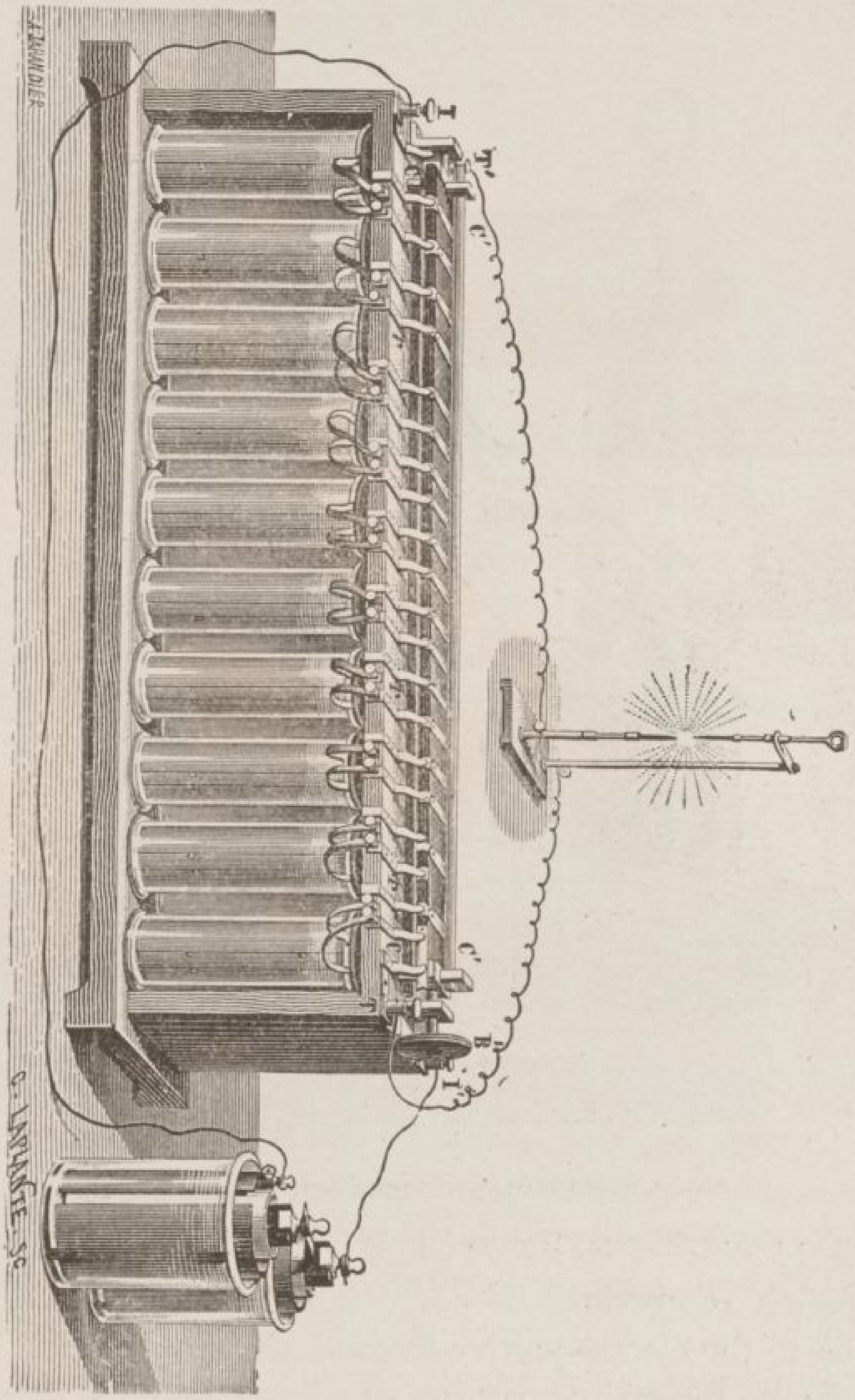


Gramme Machine. Type A.

The large machine, marked Type A, requires an engine of two or three horse-power, to run with any speed on a circuit. It is particularly well adapted to the needs of workshops, and of institutions of learning, for demonstrative requirements seldom exceed its capabilities. With a speed of 1,000 revolutions per minute, the electro-motive force is seventy-five or eighty volts, and the current strength about twenty-five ampères, while with a speed of 1,200 or 1,400 one may run three arc lights or twenty or thirty incandescent lamps. With lower speeds and less current all the demonstrative work necessary for instruction may be done in a very much more satisfactory way than is possible with any kind of a galvanic battery.

The exhibit of the Maison Breguet included many other scientific instruments of value for educational purposes.

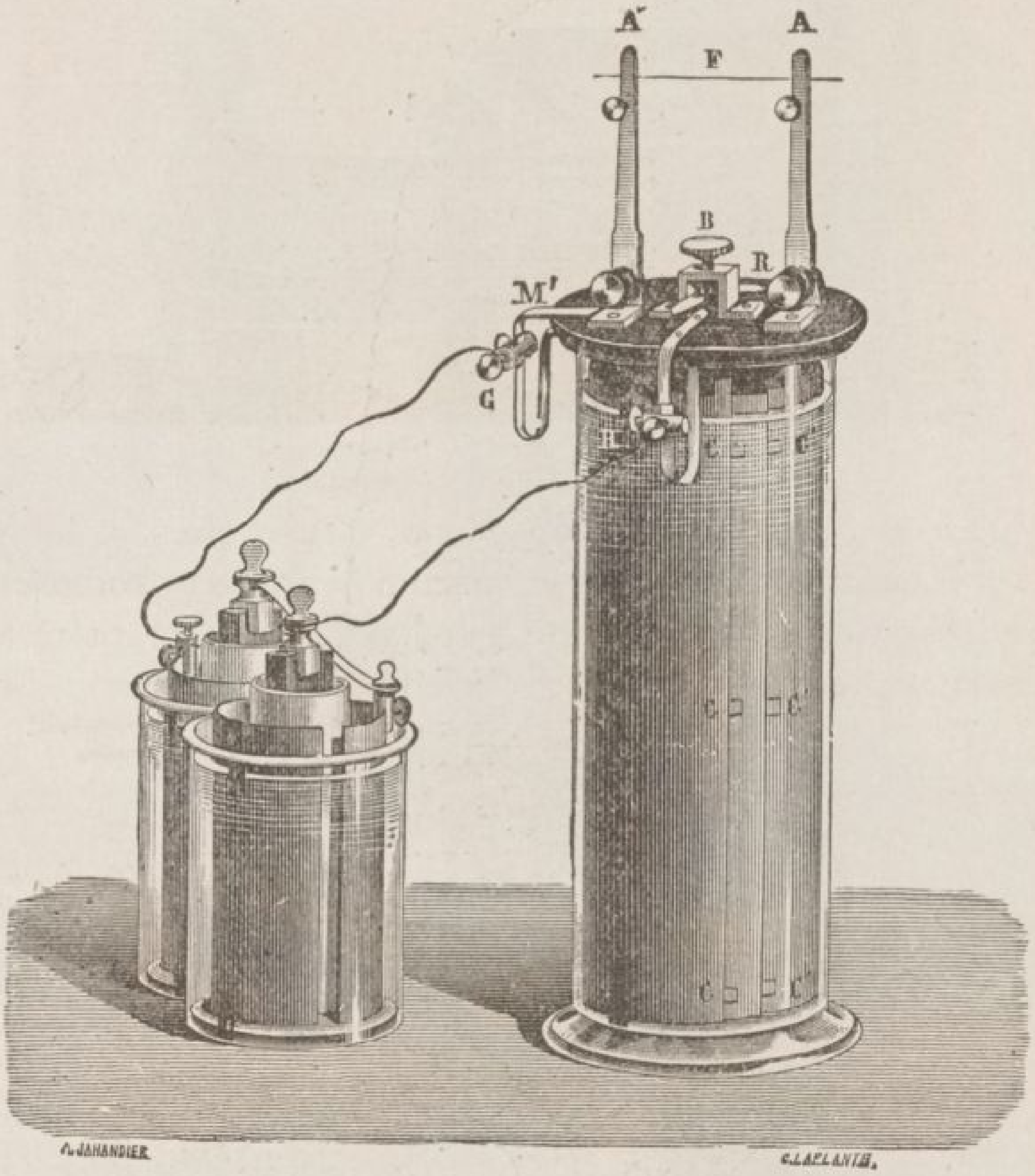
There was shown the well-known Serrin electric regulator and the Planté secondary batteries. Of these last, there was a set of twenty elements exhibited, and also several different sizes of single elements. These are useful batteries for class demonstration, and for general lecture experiments.



Set of Twenty Small Secondary Batteries.

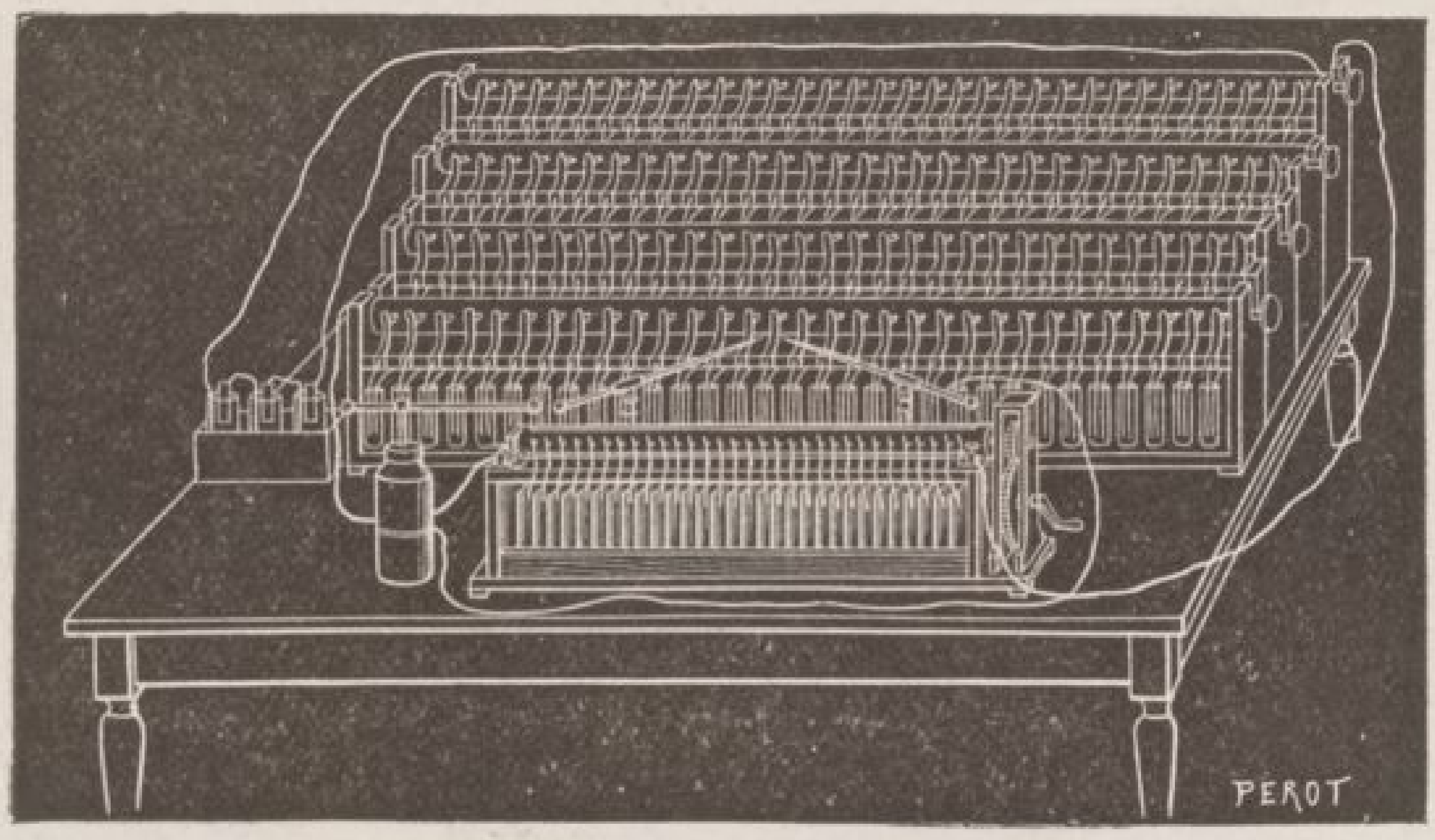
The rheostatic machine and battery of secondary couples, with zinc wire of M. Gaston Planté.

This machine is composed of fifty condensers in mica, joined to a Planté commutator by metallic spring blades, or springs, in such a manner as to be successively charged in quantity and discharged in tension. The two poles of the electric source which should charge the apparatus are joined permanently to the binding screws *P P*, whilst the sparks burst out between the points represented in cut. This spark, or flash, is in proportion to the electro-motive force of the charge. Its length has a maximum for each apparatus, which maximum is determined by the construction.



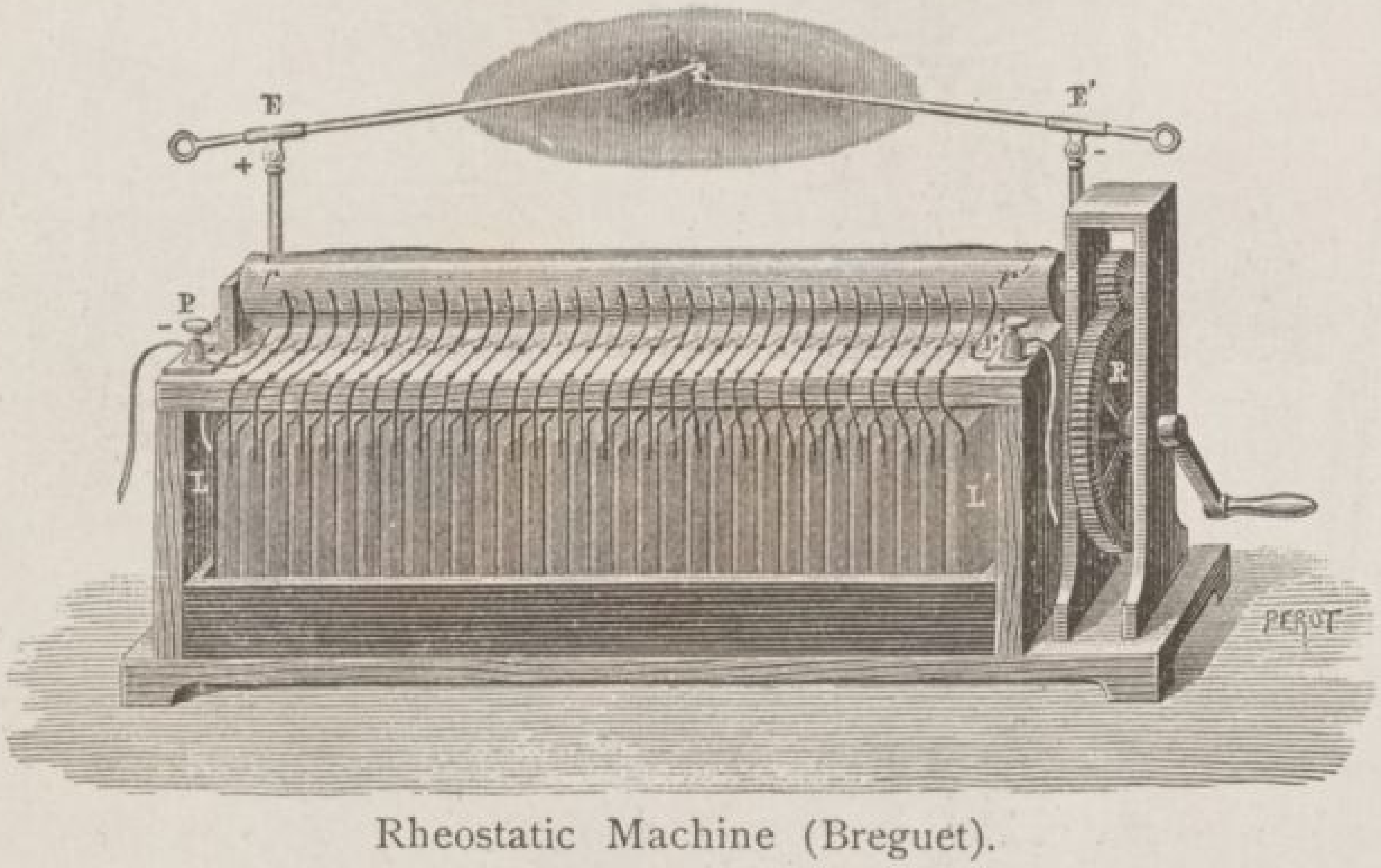
Planté's Secondary Battery.

The complete battery is formed of 320 of these small elements, divided in four batteries of eighty couples each. These eighty couples can be associated instantly by means of the commutator Planté, in quantity or in tension. These four batteries, laid out on shelves, one above the other, to put each couple in action are associated in quantity for the charge, and in tension for the discharge.



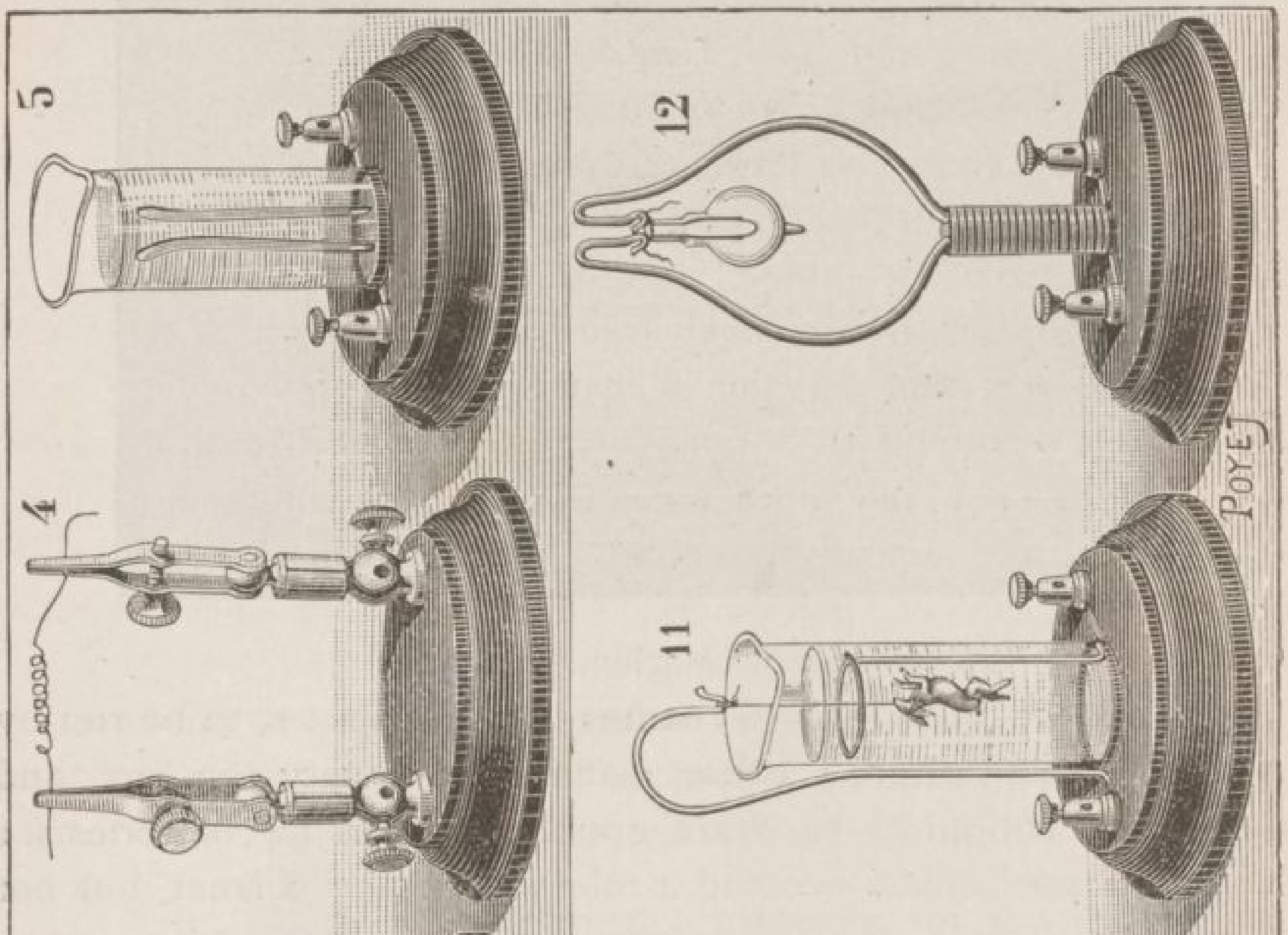
Rheostatic Machine (Breguet).

Apparatus by Gerard.—Dynamos of various sizes, to be run by hand or steam-power. These machines are very compact, and those to be worked by hand are good substitutes for batteries for the many experiments needing a tolerably steady current, but not great current strength. A small one tested gave, when run with one hand and small pulleys, an electro-motive force of fifteen volts and a current of five ampères, and developed magnetism in an electro-magnet to such an extent that one could not pull away the



Rheostatic Machine (Breguet).

armature while a current was passing. These small hand dynamos of Gerard are intended for school work, and small incandescent lamps, electro-magnets, electric bells, fuzes for explosion, etc., form a part of the collection, all adapted to be run by the current generated by hand, and they work successfully.



Accessories to Small Gerard Machine.

In order to exhibit, with satisfaction, electrical phenomena, it is more than convenient, it is necessary, that the different pieces to be used should be adapted to each other, which is not always the case when pieces are obtained without regard to adaptation, as is often the case with school apparatus. Gerard, therefore, has a series of accessories for his machines, some of which are shown in the accompanying cut, which mostly tell their own story, and show to what a variety of experiments the machine may be put.

(See reports following on hand dynamos, by Professor Anthony and Lieutenant Murdock.)

It is not an uncommon thing for comparisons to be made between hand dynamos and galvanic batteries, in which the statement is that a certain machine is equal to two or five or ten Grove cells. Such a statement is very indefinite indeed, and not a few have bought such machines expecting to get much more from them than is mechanically possible. The following exposition of the relations between such machines and the work spent on them may help one to a more correct idea.

Suppose a man to exert a constant power equal to one-tenth of a horse-power in running a dynamo in a circuit in which the total resistance is R ohms. To find the electro-motive force produced: the horse-power for a certain current is $HP = \frac{E\,C}{746}$

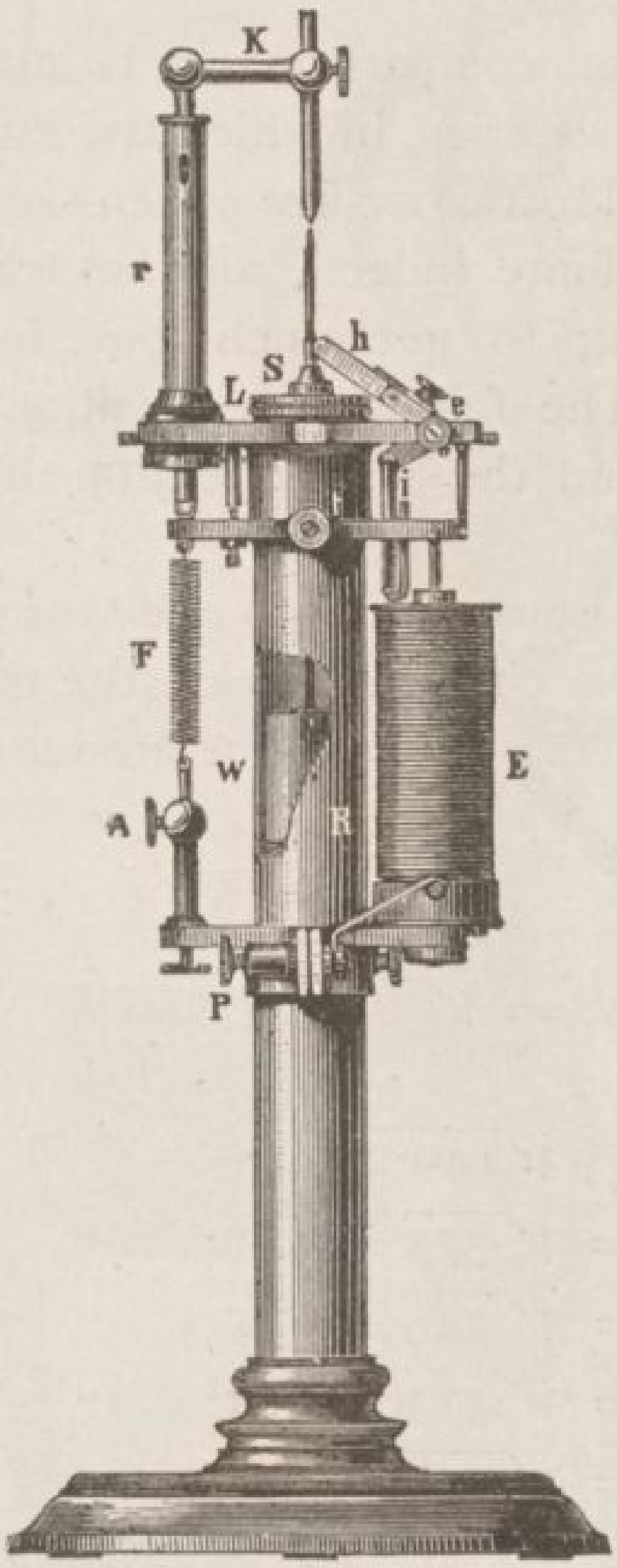
$$\text{As } C = \frac{E}{R} \therefore HP = \frac{E^2}{746\,R} \therefore E = \sqrt{HP \times 746\,R}.$$

$$\begin{array}{llll}
\text{If } HP = \frac{1}{10} & R = 2 & E = \sqrt{149{\cdot}2} = 12{\cdot}2 & \text{volts.} \\
\text{“ “ “} & R = 5 & E = \sqrt{373} = 19{\cdot}3 & \text{“} \\
\text{“ “ “} & R = 10 & E = \sqrt{749} = 27{\cdot}3 & \text{“} \\
\text{“ “ “} & R = 50 & E = \sqrt{3730} = 61{\cdot} & \text{“} \\
\text{“ “ “} & R = 100 & E = \sqrt{7460} = 86{\cdot}4 & \text{“}
\end{array}$$

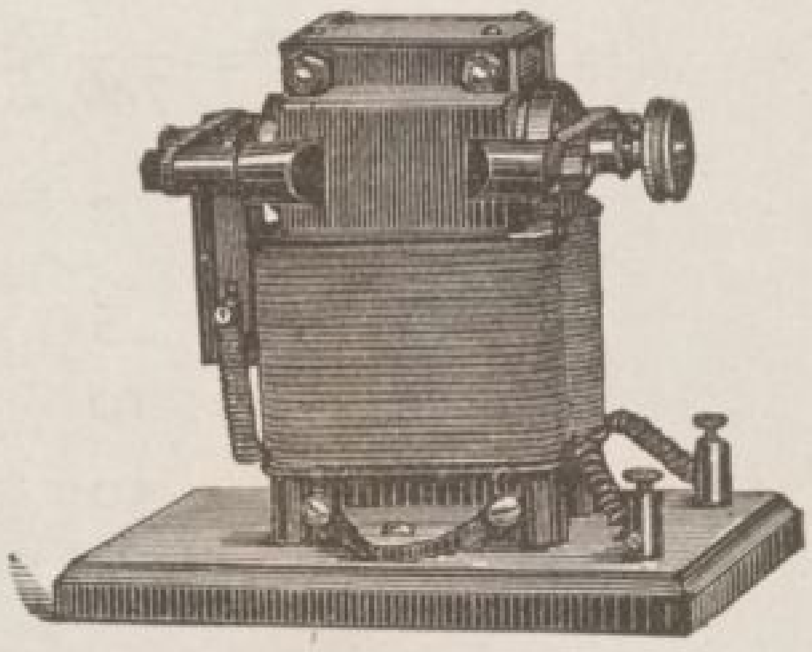
Now, one-tenth of a horse-power is more than most persons can exert except for a brief time, but the current strength for sixty-one volts and resistance fifty ohms will be but 1·22 ampères. How much of this energy will be available will depend upon the ratio of the external to the internal resistance of the machine. Hence the necessity for having the apparatus to be used with such a hand dynamo, *adapted to it.*

EXHIBIT OF C. & E. FEIN, OF STUTTGART.

Dynamos for hand working. These were conveniently and neatly mounted upon tables, and provided with numerous attachments suitable for use in the lecture room. The exhibited set of accessories was more complete than any other exhibit of similar kind, and embraced nearly everything which a teacher would want in teaching this subject. The pieces were generally of a larger size than those by other makers.



Fein Arc Lamp.



Fein Electromotor.

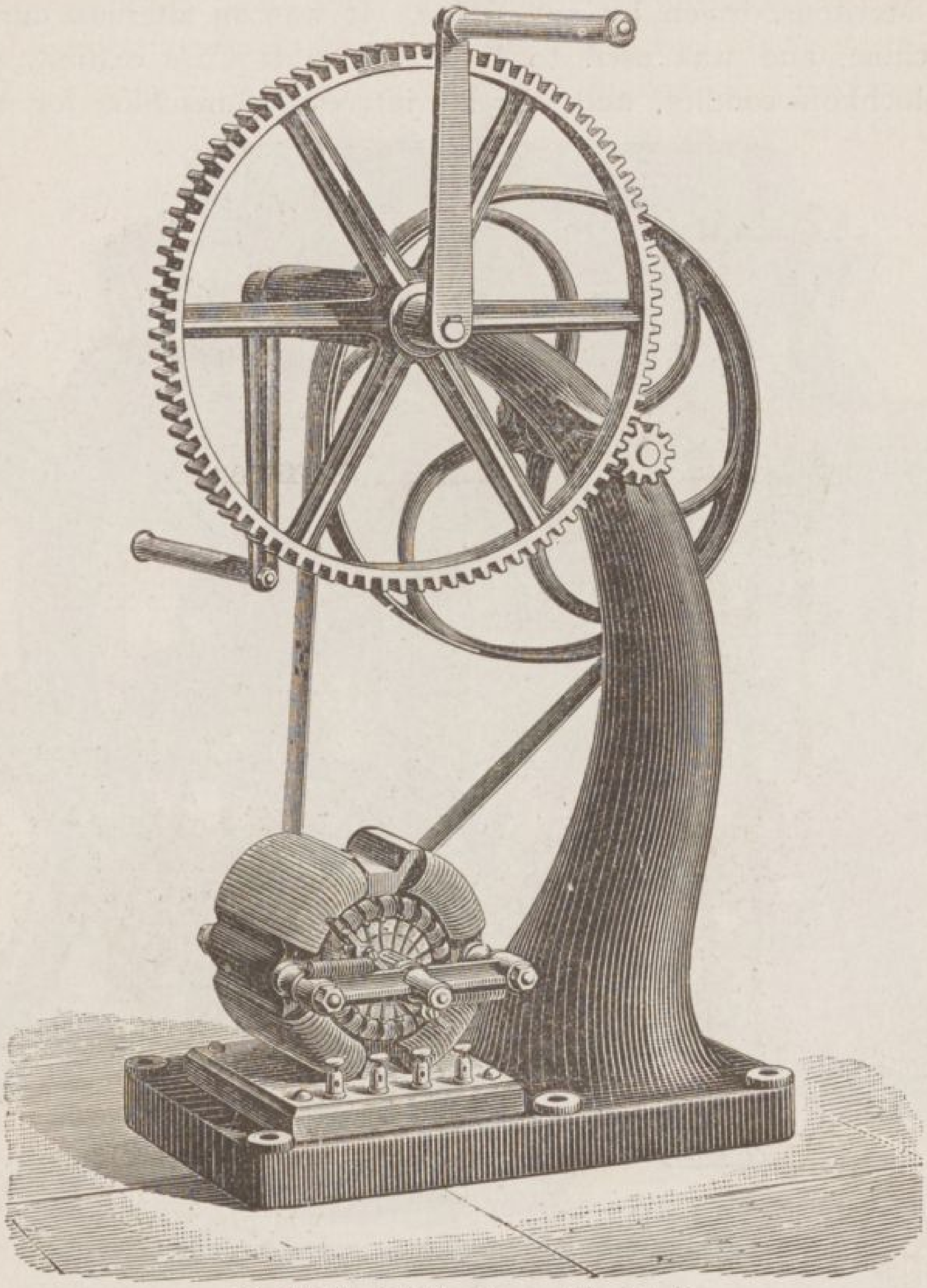
The following pieces were specially noticed:

Voltameter, electro-magnet, galvanoplastic apparatus, electromotor induction coil, incandescent lamps, arc lamps, Geissler tubes, voltameter and ampèremeter. These appeared to be all well made and adapted to their specific uses.

(See report on hand dynamo of Fein, by Lieut. Murdock.)

EXHIBIT OF A. DE MERITENS, OF PARIS.

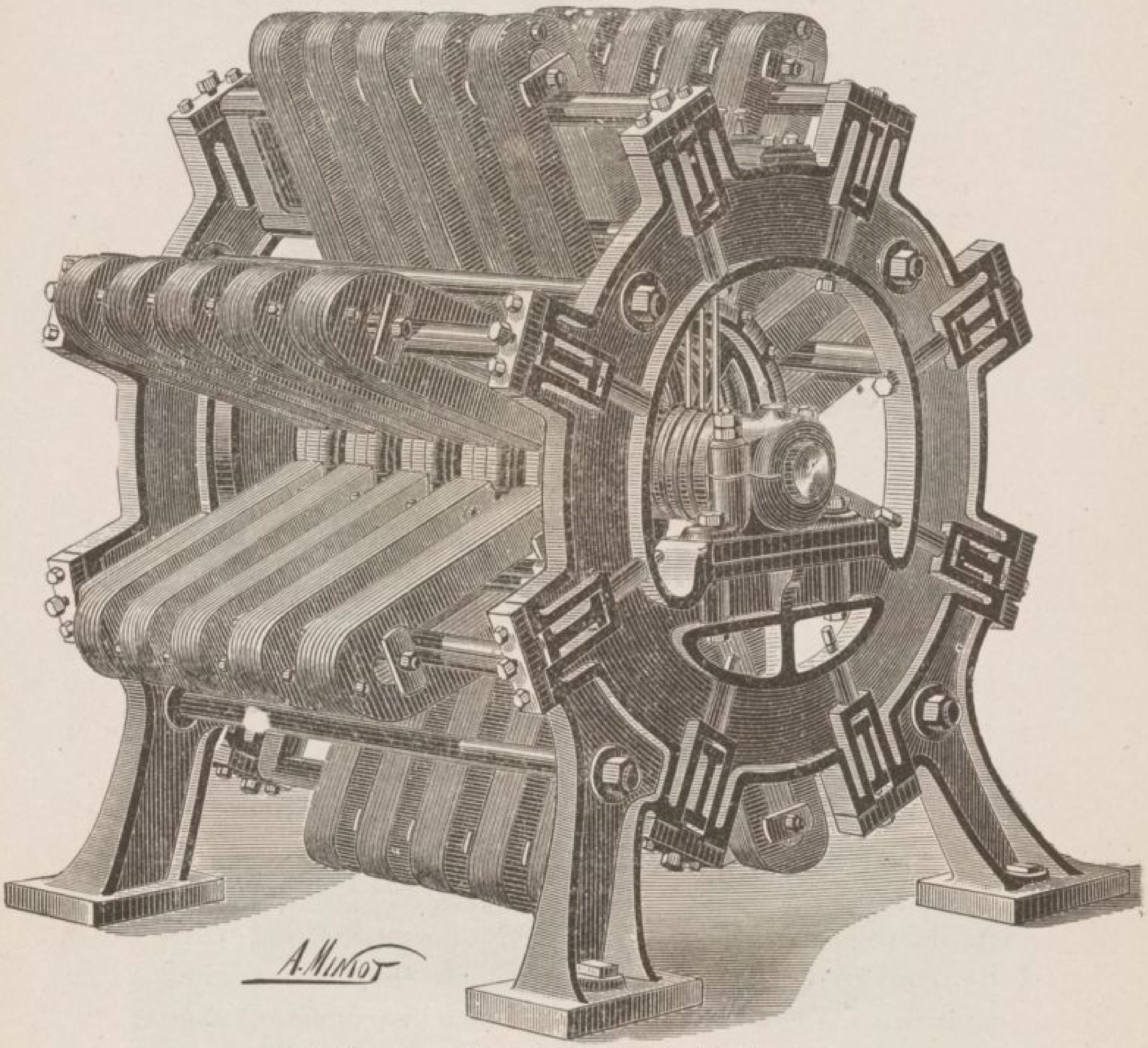
His dynamos are made in large models for supplying currents for electric lights, or for any other purpose, and require some motive-power as steam or water; and small models which may be run by hand-power, and suitable for most lecture-table experiments. The cut represents such a machine mounted to be driven by either one or two persons, and is capable of producing an arc light. The machine is so arranged that armatures with different



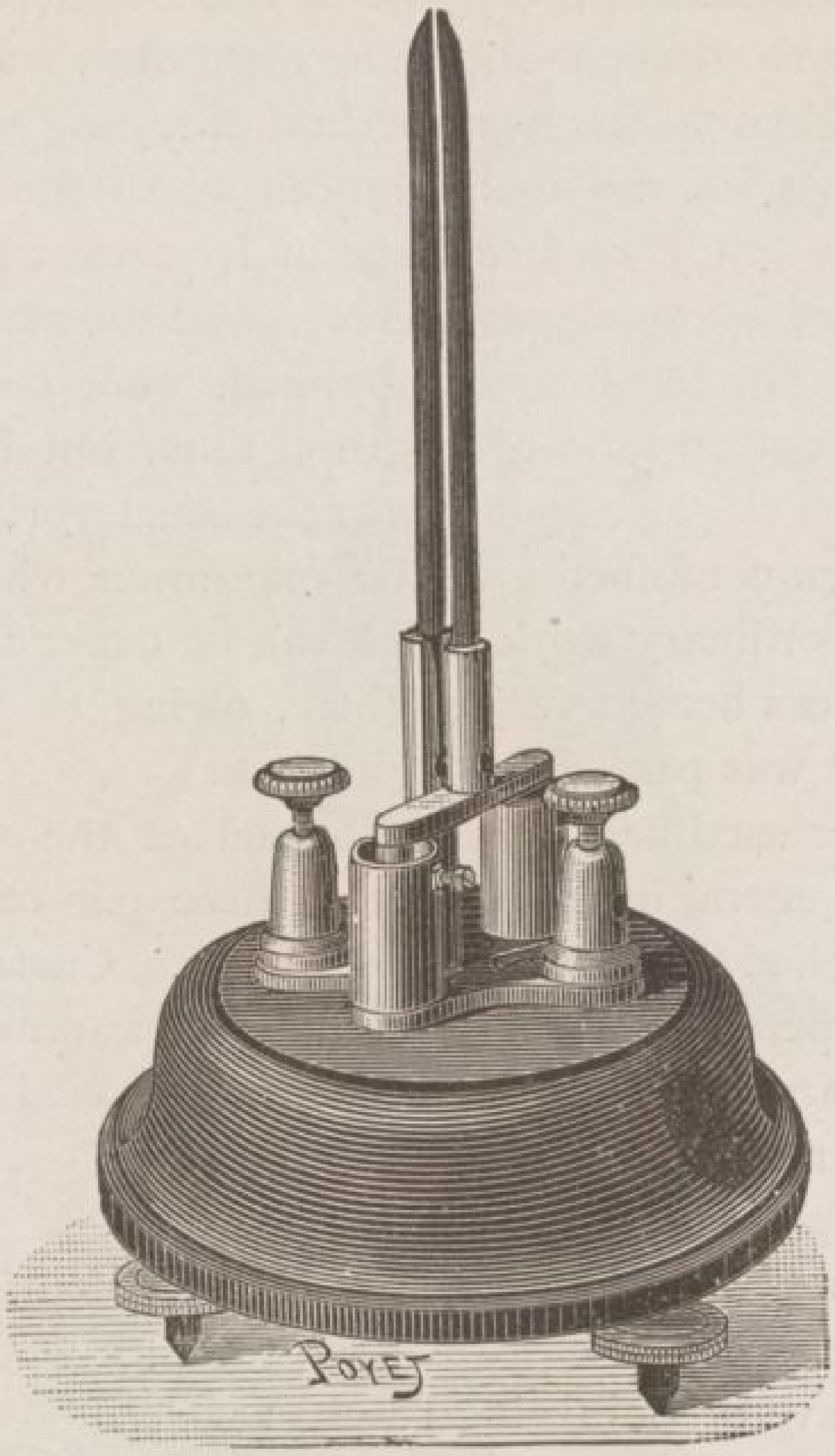
De Meritens' Machine. Model C.

resistances may be readily substituted, and thus adapted to different kinds of electrical work. The dynamos are particularly compact and efficient. Several are already in use in colleges in the United States.

There was also exhibited a large magneto-electric machine, by De Meritens, driven by an engine. It was an alternate current machine, and was used to light Queen & Co.'s exhibit, with Jablochkoff candles, and was an interesting machine for both structure and function, as such machines are not used to any extent in this country, and the Jablochkoff candles requiring such alternating currents, are now-a-days mostly displaced by the more modern arc and incandescent lamps. This machine, marked Model A, was capable of lighting thirty Swan lamps.



De Meritens' Alternating-Current Machine.



Jablochkoff Candle.

There were various interesting accessories to the exhibit of De Meritens,—brackets, commutators, Jablochkoff candle holders, globes, etc., exhibiting both taste and mechanical skill.

(See Prof. Anthony's report on De Meritens' hand dynamo.)

TEST OF HAND DYNAMOS.

At the request of Messrs. James W. Queen & Co., I tested some of the hand dynamo machines for which they are agents. The attempt was made at first to use ordinary instruments, tangent and potential galvanometers, but it was found that the irregularity of the current prevented any accurate observations, and it was impossible to turn the cranks with sufficient regularity to produce a current which could be measured. The plan was then adopted of measuring the external resistance, and determining the current by a Deprez ammeter. The resistances used were of German-silver, several being attached to the frame of one of the Fein machines. Three others, each of about six ohms resistance, were used.

It was thought that the best method of testing would be to obtain as far as possible, the maximum output of the machines, and the observations were therefore made under these conditions. The crank was turned as rapidly as possible, and the maximum current was observed. The results thus obtained, were of course higher than could be kept up for any length of time, but in most of the machines the test was also made under the usual working conditions.

The two when combined give the maximum which can be obtained, and the ordinary work which can be depended on.

The resistances heated very slightly, owing to the short time that the current was passed through them.

The ammeter used had been calibrated at the test house and found to be in general in excess about three per cent. This correction was applied to all observed currents. Currents below two and one-half ampères were measured by another ammeter, graduated to tenths of an ampère. No correction was applied to the readings of this instrument.

The above applies to all machines tested.

Two machines were exhibited by C. & E. Fein, the No. 3 and No. 10.

The No. 3 gave the following results:

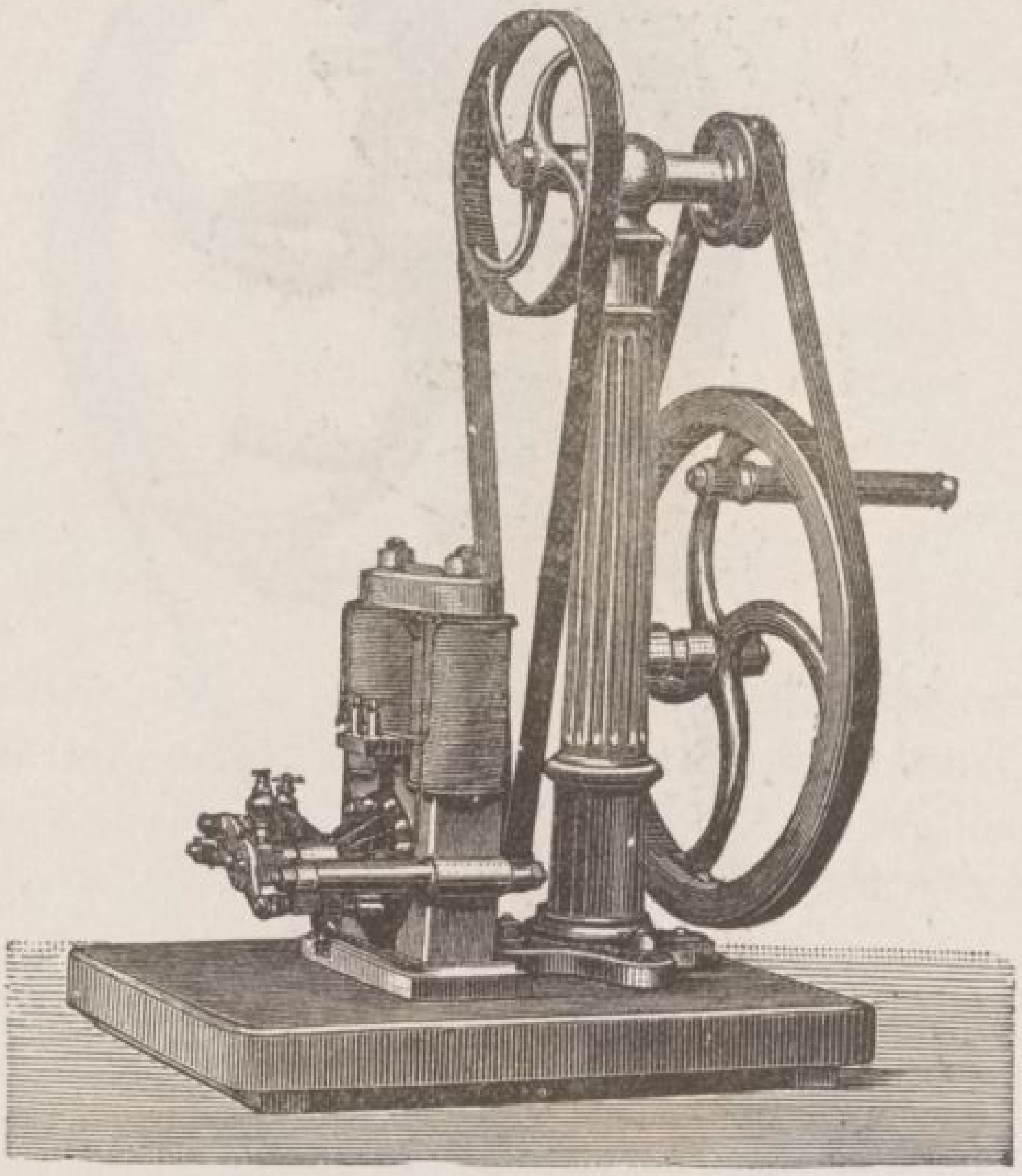
Armature Resistance,	35
Field "	26
Total,	61 legal ohms.

Current.	External Resistance.	Difference of Potential.	Total Resistance.	E M.F.
10·5	·9	9·45	1·5	15·75
10·1	1·1	11·1	1·7	17·2
8·9	1·5	13·3	2·1	18·7
7·6	1·85	14·1	2·45	18·6
6·5	2·8	18·2	3·4	22·1
3·7	5·0	18·5	5·6	20·7
1·65	7·3	12·0	7·9	12·9
1·25	8·9	11·1	9·5	11·9
·50	14·4	7·2	15·0	7·5

The results may be taken as the best capable of being obtained by a man of average strength. The best continuous working is about one-half the above E. M. F. for any given resistance.

The makers make the following statement in regard to the capacity of this machine.

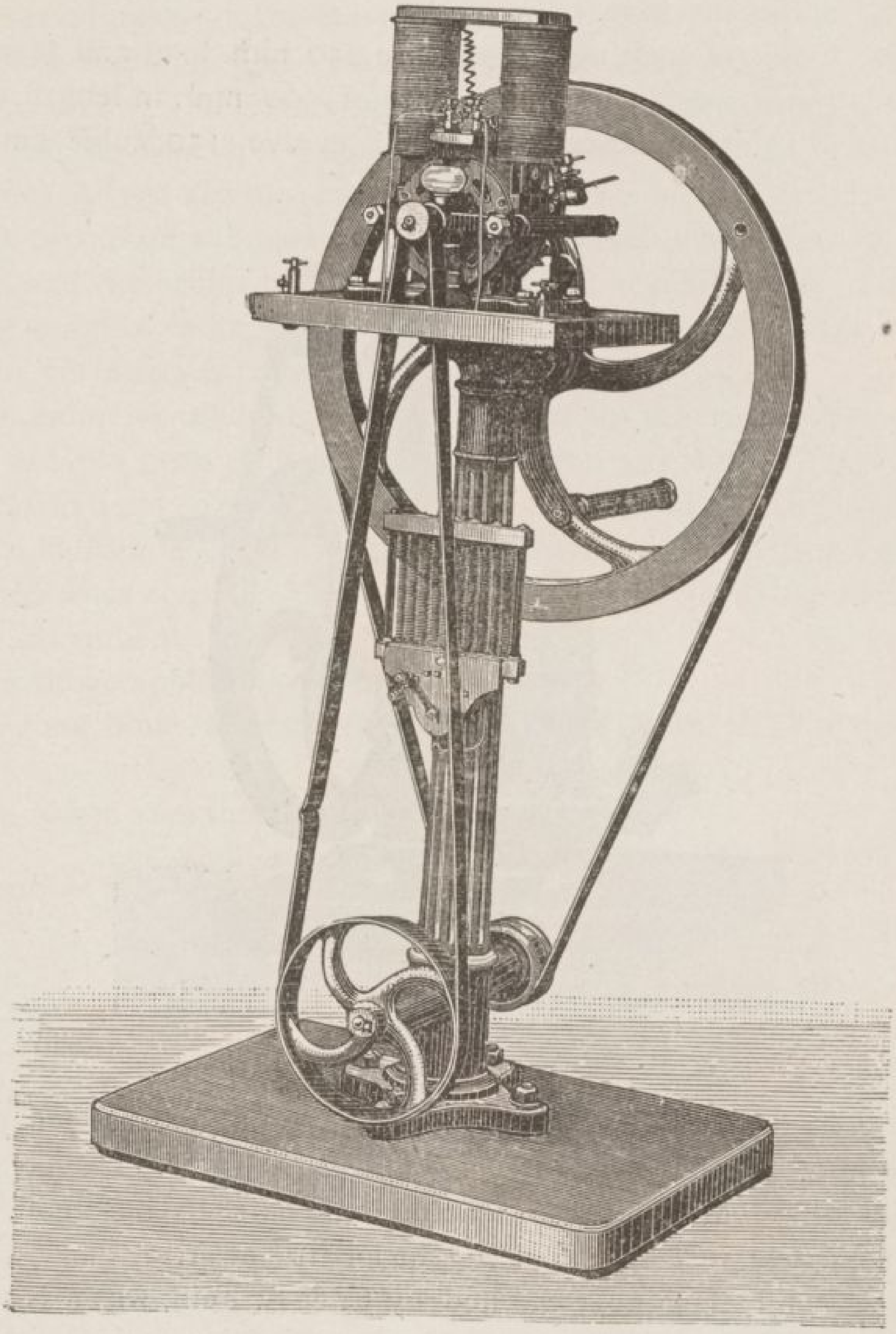
It is capable of melting a steel wire 250 mm. long and ½ mm. thick. It will make a platinum wire of 500 mm. in length, and ½ mm. thick, incandescent. It will evolve 150 cubic cm. of water gases per minute. It will deposit 280 milligrams of copper per minute.



C. & E. Fein's Hand Dynamo. (No. 3.)

The arrangement of this machine appears to be good, and quite compact, with but small weight for its power.

The second machine, exhibited by C. & E. Fein, was a No. 10, Model 1 b. This machine was the most powerful one tried, and was operated by two men on separate cranks. It has attached to its frame a set of German-silver resistances, which affords the means of modifying the external circuit at will. Some difficulty was found at first in exciting the field, but when the machine once



C. & E. Fein's Hand Dynamo. (No. 10.)

worked it gave very good results. The same method was pursued in obtaining the maximum output. The results were as follows:

Armature resistance, ... 6·32
Field " . . . . 8·82

15·14 legal ohms.

	Current.	External Resistance.	Difference of Potential.	Total Resistance.	E. M. F.
Maximum work with two men.	4·9	·9	4·4	16·0	78·4
	4·8	1·1	5·3	16·2	77·8
	4·9	1·5	7·3	16·6	81·3
	4·0	8·9	35·6	24·0	96·0
	3·7	15·7	58·1	30·8	114·0
	3·6	22·3	80·3	37·4	134·6
	3·3	28·6	94·4	43·7	144·
Continuous working, two men.	2·0	28·6	57·2	43·7	87·4

As illustrating the uses of machine No. 10, the maker states that it will melt a steel wire 1 metre long and 0·15 mm. thick. It will make incandescent a platinum wire 2 metres long and 0·15 mm. thick, and it evolves 150 cubic centimetres of gas per minute. It will deposit 250 milligrams of copper per minute.

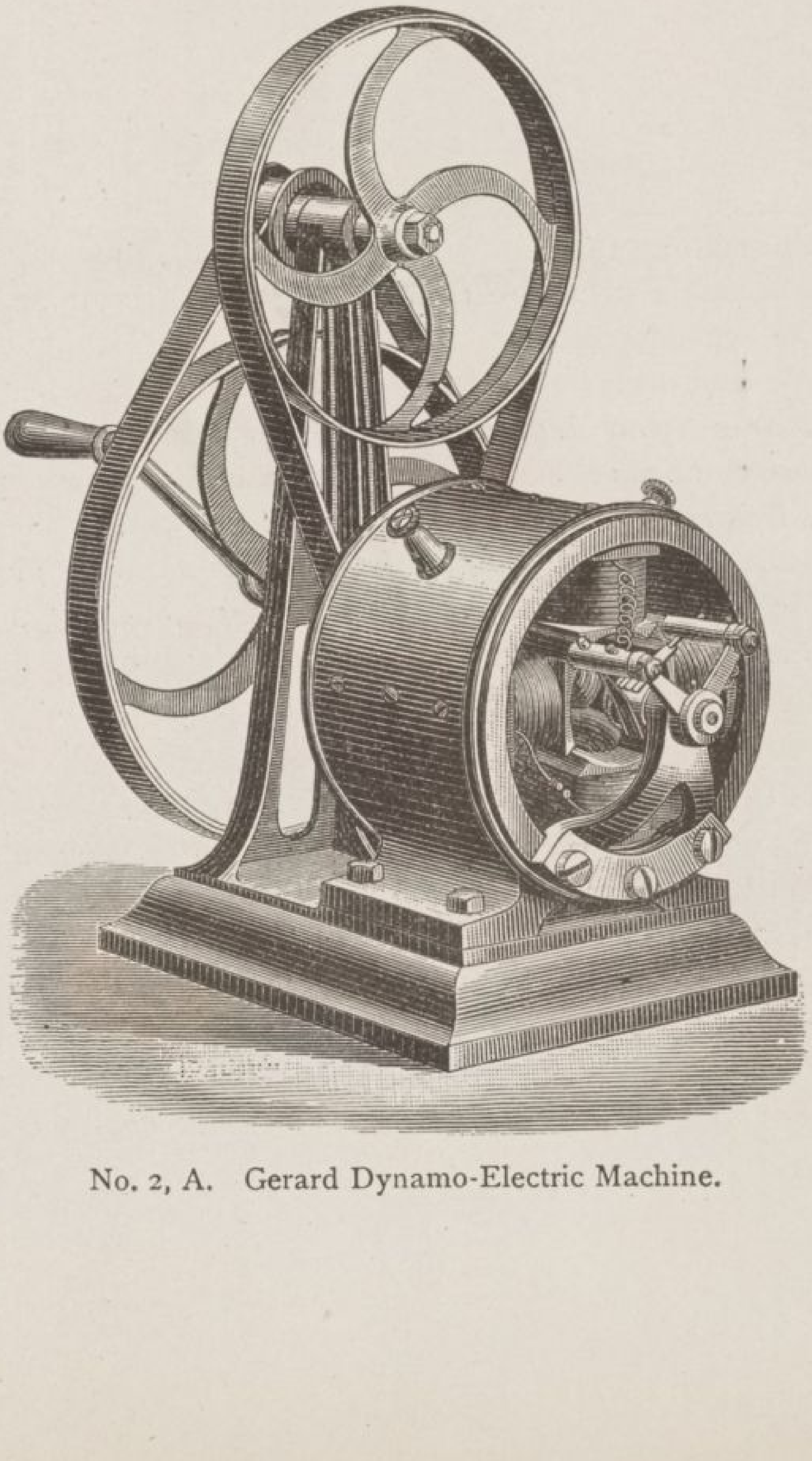
This machine is of such capacity as to admit of demonstrating almost anything which can be expected of a dynamo machine. As it is capable of being worked by two men, its output is very large, and as seen by the figures of the test, it would bring to normal incandescence for a short time five ordinary Edison lamps, and would maintain several lamps of low potential, when worked continuously by two men.

The preceding machines are made wound with either coarse or fine wire. No. 3 machine tested, was wound with coarse wire, and No. 10 with fine wire.

Another machine tested was a Magneto-Gramme machine, from the Maison Breguet. It differed materially from the others apart from its being a magneto machine, in having a very small internal resistance, which would adapt it to a very different class of experiments.

Current.	External Resistance.	Difference of Potential.	Total Resistance.	E. M. F.
10·4	·95	9·88	1·01	10·50
9·2	1·15	10·58	1·21	11·13
7·1	1·55	11·00	1·61	11·43
5·4	1·85	9·99	1·91	10·31
4·7	2·75	12·92	2·81	13·21
2·4	5·05	12·12	5·11	12·26
1·75	6·40	11·20	6·46	11·31
1·30	7·90	10·27	7·96	10·36

No attempt was made to preserve a constant speed. One man turned the crank as rapidly as possible, and the maximum current was noted.



No. 2, A. Gerard Dynamo-Electric Machine.

Another machine tested was the Gerard, laboratory model, No. 0, with pulley and crank. This showed much less power than the others, being tested in the same way, with the following results:

Armature resistance,	1·32
Field "	4·93
Total internal resistance,	6·25

Speed.	Current.	External Resistance.	Difference of Potential.	Total Resistance.	E. M. F.	
2,600	3·5	·85	3·0	7·10	24·90	Maximum.
2,700	1·4	7·15	10·	13·4	18·80	"
3,500	1·0	13·75	13·8	20·0	20·0	'
3,200	·5	20·55	10·28	26·8	13·4	"
2,300	·7	7·15	5·	13·4	9·4	Easy working.
1,900	·3	13·75	4·1	20·0	6·0	"
	·25	20·55	5·1	26·8	6.7	

Reported by
J. B. Murdock.

Report upon Small Machines (dynamos), submitted by James W. Queen & Co., and Tested at the Physical Laboratory of the Cornell University, in January, 1885.

APPARATUS USED.

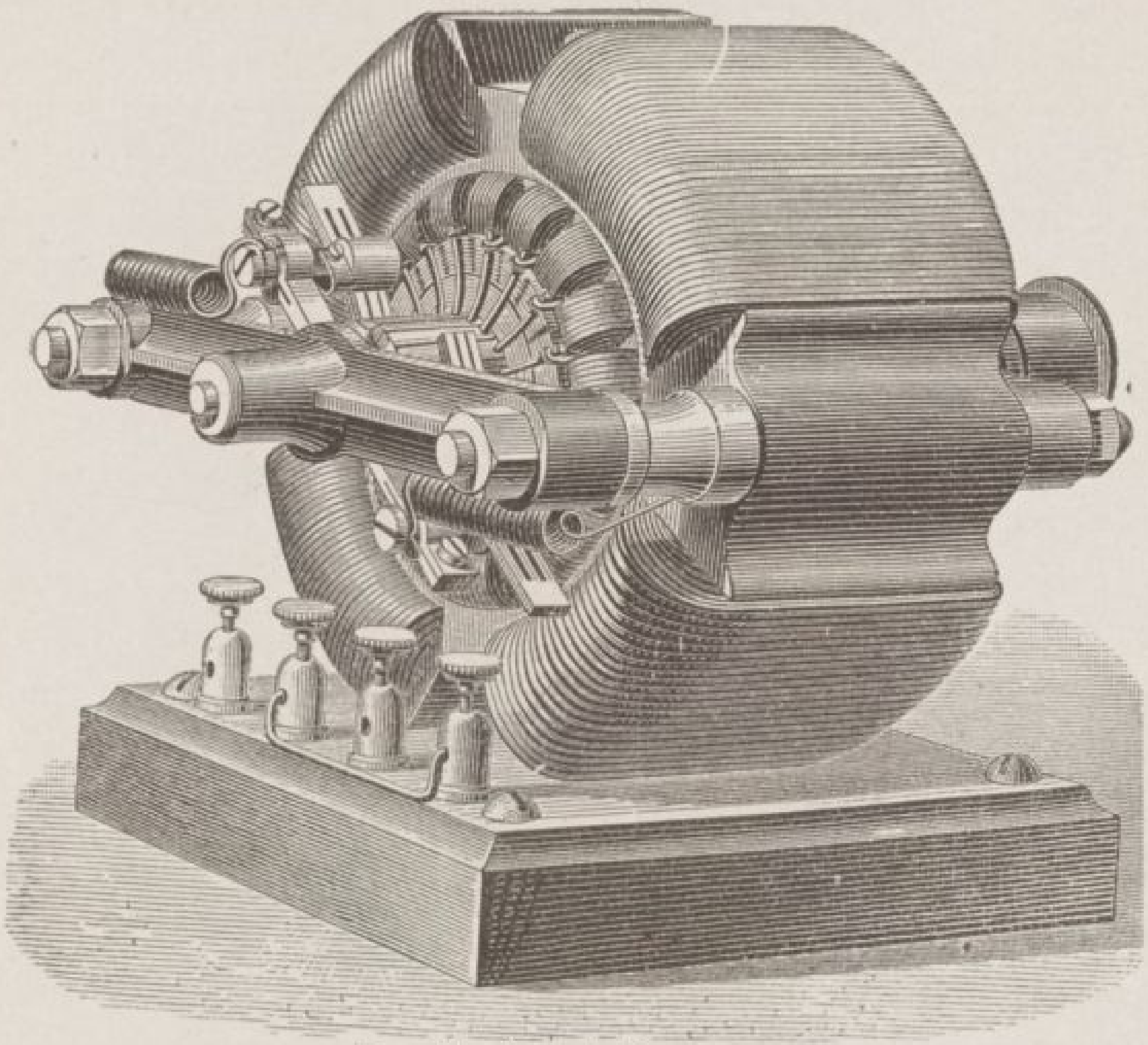
(1.) *Power Measurements.*—It was at first proposed to place the machines on a small Brackett cradle, but, as the adjustment consumes considerable time, it was thought best to use, as a motor, a Gramme machine, constructed ten years ago at the University, and which is mounted permanently on a very delicately balanced cradle. Having at hand a ten-light Weston dynamo, used for lighting the University campus, it was easy, using this as a generator, to obtain from the Gramme, as a motor, any power required, up to five or six horse-power. The Weston ten-light machine was provided with an adjustable resistance for the field circuit, which gave the most complete control of the current generated, and, therefore, of the speed of, and energy transmitted by, the Gramme. Under these conditions, the Gramme was a very easily managed and exceedingly delicate transmitting dynamometer. The speed of the Gramme was indicated continuously by a Buss "Tachymeter," but was also frequently taken by a speed counter, as well as the speed of the machine under test.

(2.) *Current Measurements.*—The currents were measured by a tangent galvanometer, whose conductor was a turned brass ring, fifty centimetres diameter, and a Thomson graded galvanometer. As H was not accurately known for the position of the tangent galvanometer, the constants of the instruments were determined by the copper voltameter. In the experiment for this purpose, two voltameters were placed in series, and the current continued for 100 minutes. Readings of the galvanometers were taken every four minutes. The extreme deflections were 40° 24′ and 41° for the tangent, and 31·6 and 32·7 for the Thomson. The deposit of copper was, in one cell, 10·477 grammes; in the other, 10·479 grammes; giving for the tangent galvanometer, 6·15; for the Thomson galvanometer constant, ·1644.

(3.) *Resistance Measurements.*—Resistances were measured by means of a dial pattern resistance box, by Elliott Brothers, adjusted to B. A. ohms. Resistances have not been reduced to legal ohms. The machines were run on a dead resistance of German-silver wire wound on a reel, and so connected that it formed one branch of a Wheatstone's balance, the other branches of which could not be appreciably heated by the current. By this arrangement, the resistance could be measured at any time while the current was flowing.

(4.) *Potential Measurements.*—The potentials between the terminals of the machines were measured by means of a Thomson potential galvanometer checked by an Ayrton and Perry voltameter. The constants of both these instruments were determined at the same time as the constants of the current galvanometers, by noting the deflection when they were connected to each side of the German-silver wire, whose resistance was determined while the current was passing by the means described above. In these measurements the power may be considered accurate to about $\frac{1}{100}$; current to about $\frac{1}{100}$; resistance to about $\frac{1}{300}$; potentials to about $\frac{1}{100}$.

The readings of the various instruments during any test were generally very constant. If any considerable variations occurred, the test was repeated. Computations have been made independently by two persons, and it is believed that the results given are free from errors. In the tests of the machines, they were run at what was supposed to be the normal speed for some time, until instruments gave uniform readings, then readings were taken each minute for ten minutes. The resistance in the external circuit was then changed and another set of readings taken. Below are given the general results of the observations:



De Meritens' Dynamo.

Small De Meritens' Machine.—Shunt wound, armature of the Gramme type.

Weight of machine, ...	68 pounds.
Resistance of armature, ...	1·36 ohms.
" " field, ...	70·7 "

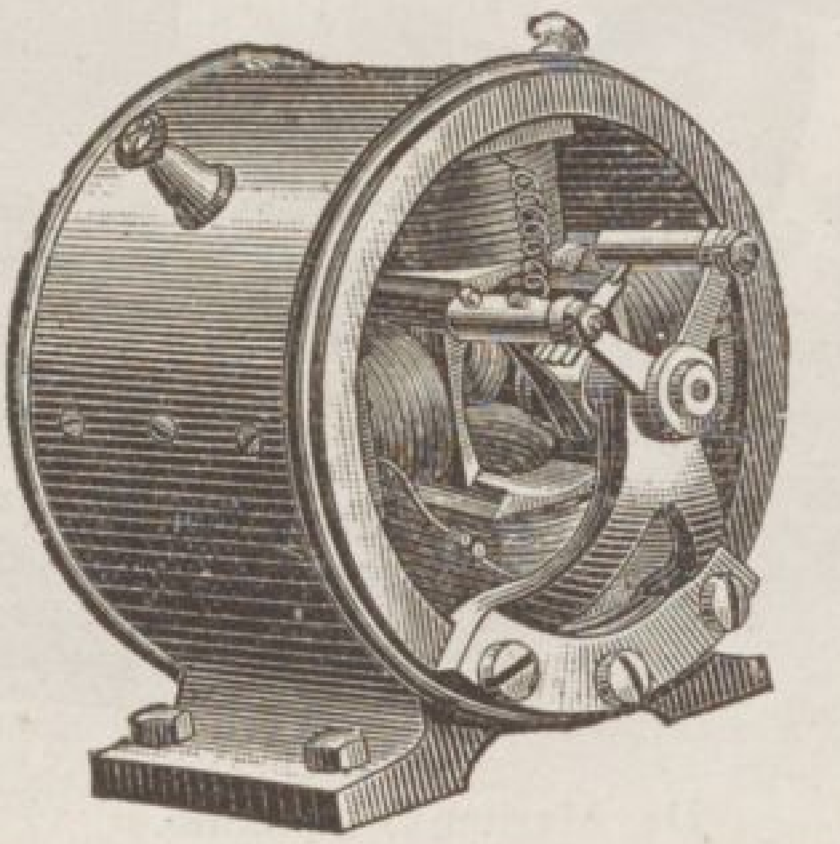
Current — *C.*	Potential at Terminals — *E.*	External Resistance — *R.*	Energy in External Circuit $= CE.$	Power given to Machine $= W.$ (*Watts.*)	Commercial Efficiency $= \frac{CE}{W}$	Revolutions per Minute.	Power Consumed *HP.*
6·88	49·4	7·18	339·9	686·5	49·5	3,240	·92
6·54	37·1	5·67	242·6	553.9	43·8	3,200	·74
5·56	21·8	3·9	121·2	401·3	30·2	3,300	·54

It will be noted that this machine gave the greatest current with the greatest external resistance. The strength of field therefore diminished as the external resistance diminished. Possibly, better results as to efficiency might have been obtained with a still greater resistance.

The machine worked a Foucault lamp very well, but in order to start the lamp it was necessary to carefully separate the carbons by hand, as, with the small external resistance existing when the carbons were in contact, the machine would not excite itself.

NO. 230. CATALOGUE OF QUEEN & CO.

Small Gerard Machine, No. O^5.—Shunt wound, armature of four pole pieces projecting radially from the axis. On each pole piece was a coil of wire. The commutator flashed badly at high speeds. Twenty-five hundred revolutions per minute was the highest speed it could safely run.



Gerard Dynamo Machine. (No. o^5.)

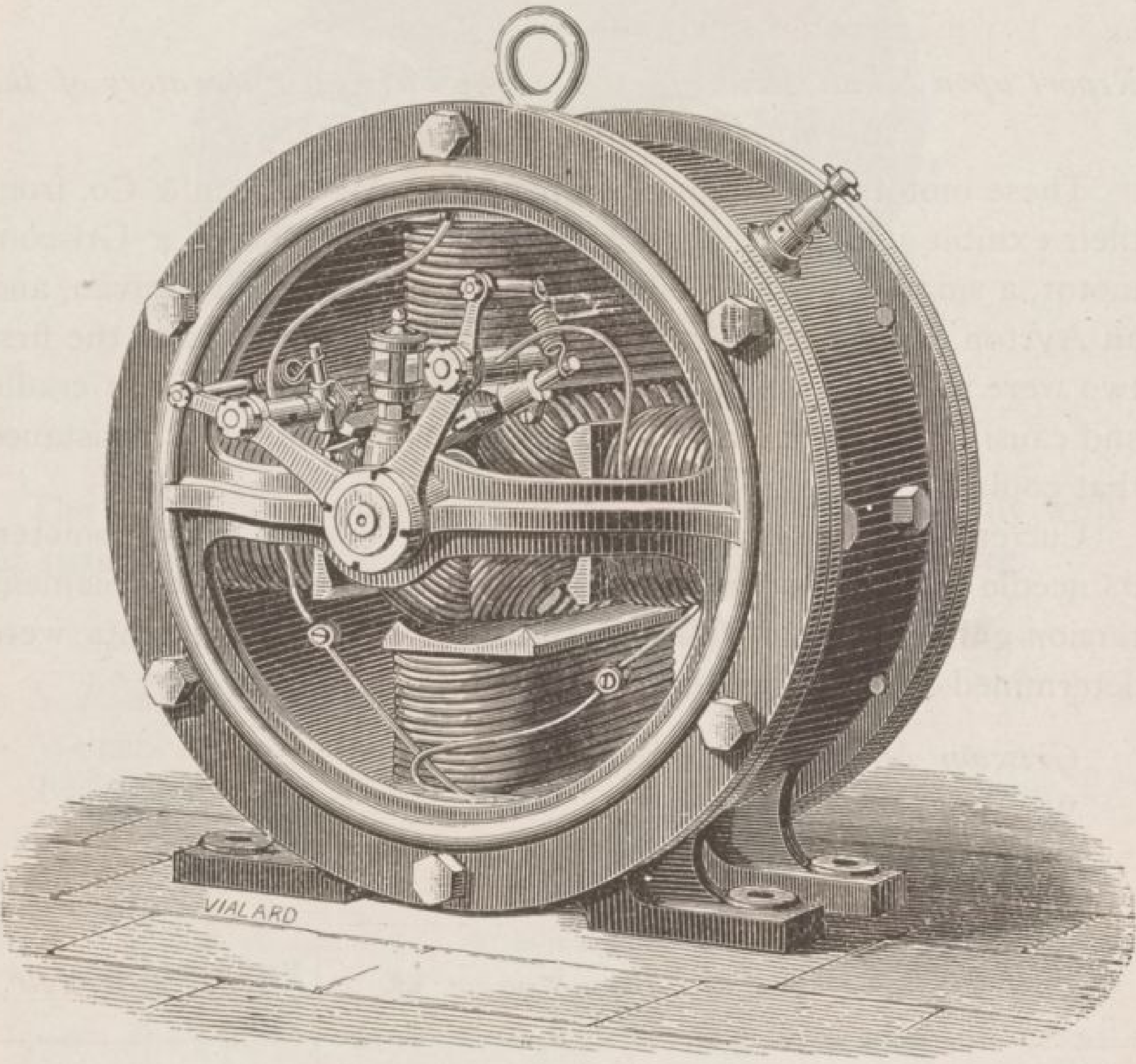
Weight of machine, ...	47 pounds.
Resistance of armature, ...	·199 ohms.
" " field, ...	17·88 "

Current = *C.*	Potential at Terminals = *E.*	External Resistance = *R.*	Energy in External Circuit = *C E.*	Power given to Machine = *W.* (*Watts*)	Commercial Efficiency $= \frac{C\ E}{W}$	Revolutions per Minute.	Power given to Machine in *HP.*
4·09	29·04	7·1	118·8	381·2	31·2	2,350	·511
5·33	31·08	5·85	165·7	433·3	38·2	2,590	·581
7·33	28·62	3·9	209·8	433·3	48·4	2,500	·581
7·73	21·8	2·82	168·5	426·4	39·5	3,330	·572
Brushes readjusted and tension of springs increased.							
5·154	36·6	7·1	188·6	556·3	33·9	2,670	·745

Large Gerard Machine No. 3.—Construction similar to small machine.

Weight,	327 pounds.
Resistance of Armature,	·24 ohms.
" " Field,	11·96 "

Current. C.	Potential at Terminals. E.	External Resistance. R.	Energy in External Circuit. CE.	Power given to Machine. W. (Watts.)	Commercial Efficiency. $\frac{CE}{W}$	Revolutions per Minute.	Power given to Machine in HP.
10·76	80·66	7 94	867·9	2,585	33·6	1,356	3·47
10·39	71·3	6·86	740 8	2,443	30·3	1,390	3·27



Gerard Dynamo Machine. (No. 3.)

To determine how much of the loss in this machine was due to friction and how much to induced currents in the mass of the magnets and armature, the brushes were thrown back and the machine driven at the same speed as in the above experiments. When the field was unmagnetized the power required was 147 watts = ·2 horse-power.

When field was magnetized by another machine having a potential of fifty-four volts, about three-fourths the potential of the Gerard machine, when magnetizing its own field, the power consumed was 830 watts or 1·11 horse-power.

In the circular describing the above machine, the normal speed was given as 1,600. In my experiments, at any speed above 1,400, the flashing at the commutators was so great as to endanger the machine. Below 1,400 there was no flashing and the machine ran quite smoothly.

WILLIAM A. ANTHONY.
Profr. of Physics, Cornell University.

Report upon Small Motors Tested at the Physical Laboratory of the Cornell University, in January, 1885.

These motors were submitted by James W. Queen & Co. from their exhibit at the Electrical Exhibition. They were a Griscom motor, a small motor of English manufacture, name not given, and an Ayrton & Perry motor. The power measurements of the first two were made by mounting the motor on a small Brackett cradle and causing it to drive a small machine which offered a resistance that could be varied at pleasure.

Current was measured by the Thomson current galvanometer, its needle in the most sensitive position, and potential by Siemens torsion galvanometer. The constants of these instruments were determined as described in the report on dynamos.

Griscom Motor.—

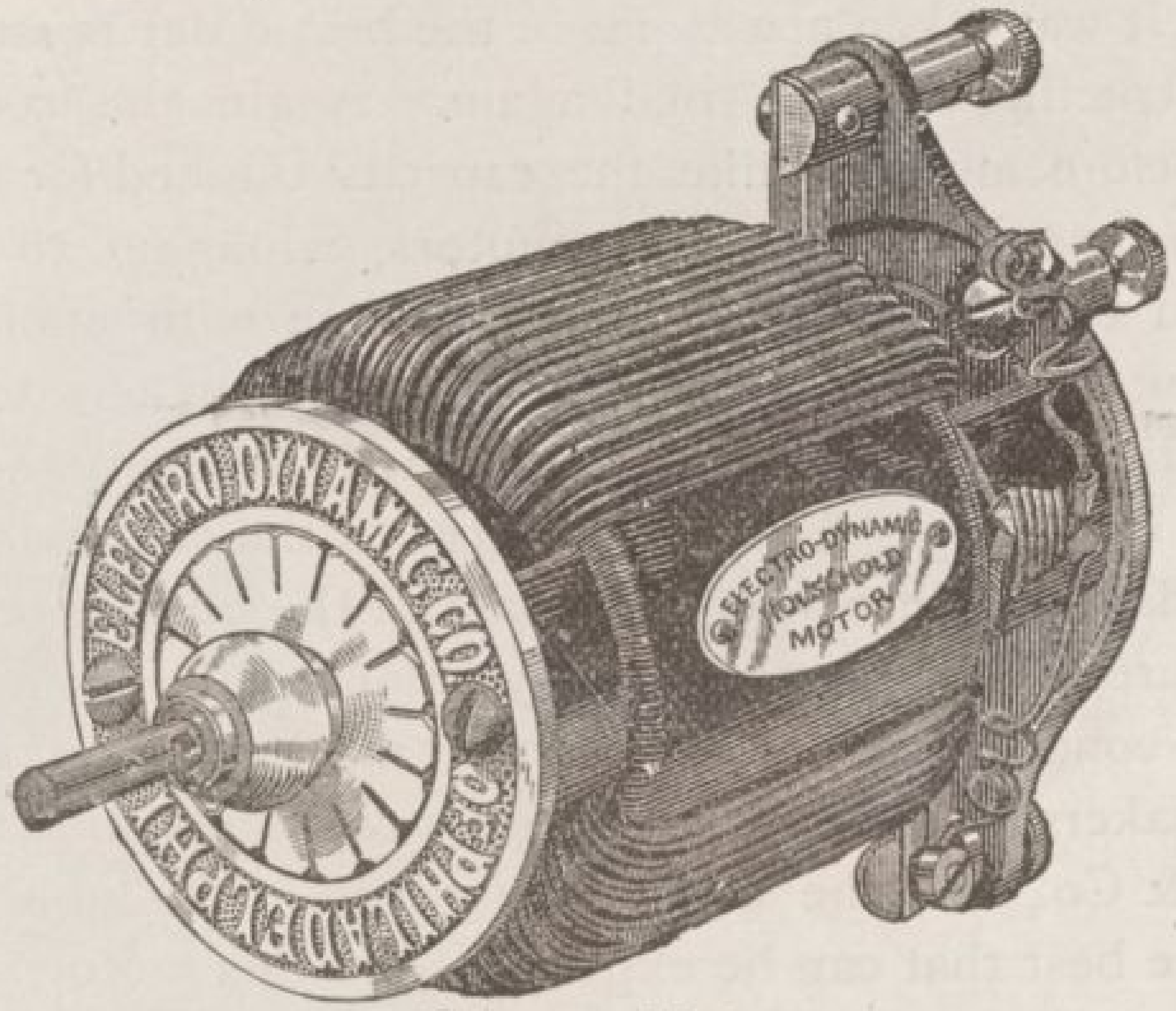
Weight, ... about 2½ pounds.
Resistance of field, ... ·616
" " armature, ... ·395

C.	*E.*	*E C.*	*W.* in Watts.	Eff.	Revolutions per Minute.	*W.* in *HP.*
3·81	7·84	29·87	6·86	23·	2,740	·0092
4·28	10·80	46·22	14·84	32·1	5,100	·0199
4·25	10·74	45·64	16·	35·	4,720	·0214
4·57	10·17	46·48	14·21	30·6	3,780	·0191

In this table and those that follow—

C = current through motor in ampères.
E = difference of potential between terminals.
CE = electrical energy supplied to motor in watts.
W = work delivered by motor in watts.

The other columns explain themselves. In the first experiment recorded above, the potential 7·84 volts, was supposed to be less than the normal potential for the motor. In the subsequent experiments a higher potential was therefore used.



Griscom Motor.

The motor ran during all the experiments very smoothly without sparking at the commutator, and without undue heating.

NO. 353, CATALOGUE OF QUEEN & CO.

S. P. Thompson Motor.—

Weight, ...
Resistance of field, ... ·47 ohms.
" " armature, ... ·373 "

C.	E.	E C.	W. in Watts.	Eff.	Revolutions per Minute.	W. in HP.
5·33	9·664	51·51	13·55	26·3	2,333	·0182
4·74	10·29	48·77	13·19	27·0	3,360	·0177
4·11	11·49	47·22	19·72	41·8	4,320	·0264
3·865	8·74	33·78	13·50	40·	3,000	·0181

Some trouble was experienced in keeping the brushes of this motor in the best order. It was only by frequent readjustment that so good work, as is shown by the above table, was obtained.

A commutator and brushes, well constructed, would make of this a very useful motor.

NO. 322, CATALOGUE OF QUEEN & CO.

The Ayrton & Perry Motor, submitted by Queen & Co., was tried, but before any considerable power could be obtained from it, the commutator caught fire and made it necessary to stop the machine. It was taken apart, put in the best order possible, without reconstructing it, and tried again. Again the commutator took fire, before anything like the capacity claimed for the motor had been reached. Two similar motors, belonging to the University, had been tried some months before with similar results. The commutator of one of these, said by the makers to be good for a potential of 100 volts, had been partly reconstructed in the University workshop. The spaces between the commutator strips had been filled with insulating material and the brushes remodelled. The armature also had been carefully balanced.

In this condition it was a far better machine than as it came from the makers. It was tested in place of the machine submitted by Queen & Co., and the results are given in the table below, as showing the best that can be expected from this motor, without a radical change in its construction. A higher electro-motive force and higher speeds were tried, but with these there was a continuous flame at the commutator.

Weight of motor, ...	38 pounds.
Resistance of field, ...	0·57 ohms.
" " armature, ...	1·92 "

C.	*E.*	*E C.*	*W.* in Watts.	Eff.	Revolutions per Minute.	*W.* in *HP.*
8·34	59·75	498·32	141·9	28·5	1,500	·19

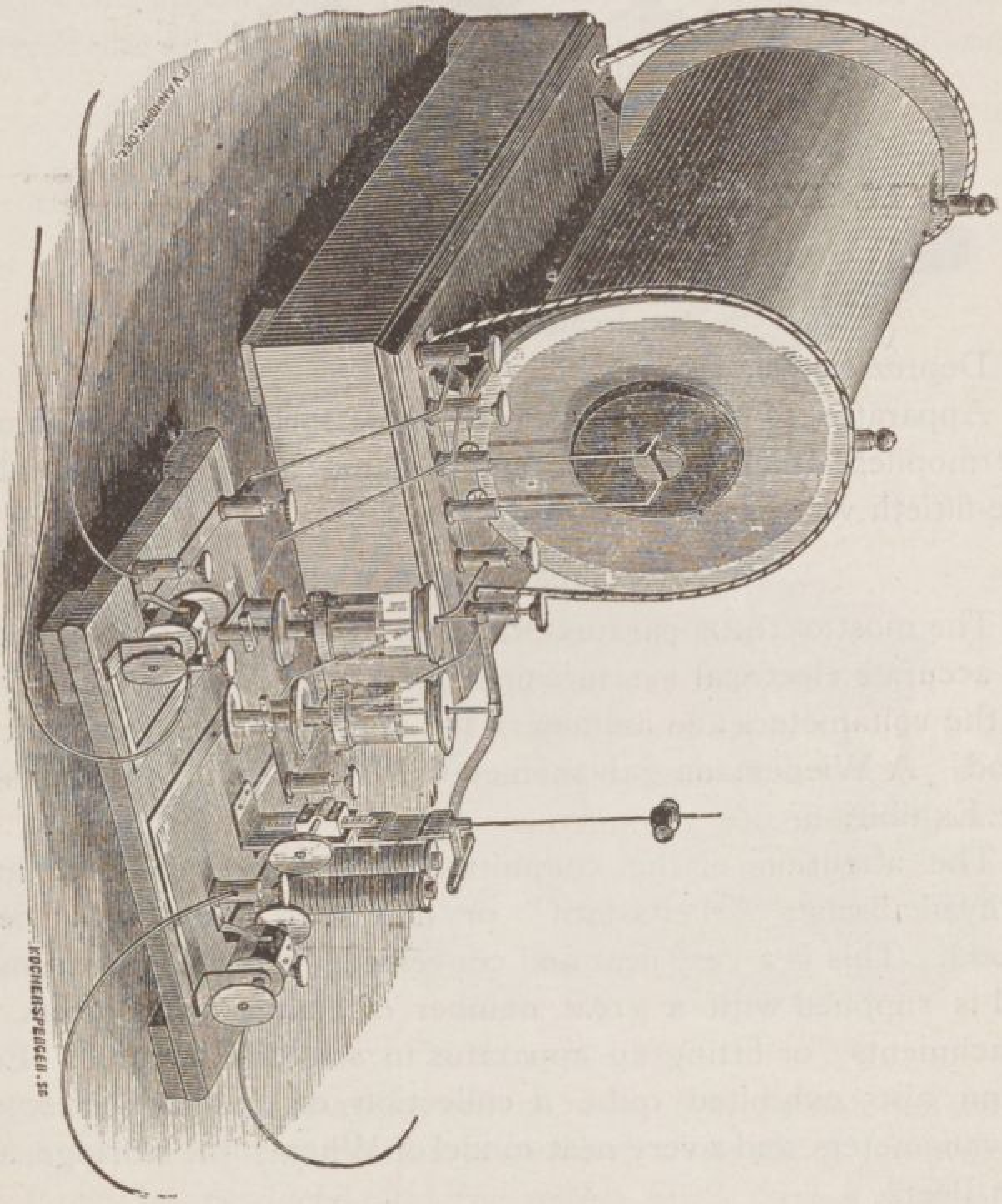
It should have been stated that the power delivered by this motor was measured, by making it drive a dynamo mounted on a Brackett cradle. The current of this dynamo could be perfectly controlled and, therefore, the power which it absorbed could be regulated at pleasure.

WM. A. ANTHONY,
Profr. of Physics, Cornell University.

EDUCATIONAL EXHIBIT OF J. CARPENTIER, OF PARIS.

J. Carpentier is the successor of the renowned Ruhmkorff, and the apparatus exhibited was in every way creditable for both manufacture and performance. The variety was great, and the following pieces were especially noted.

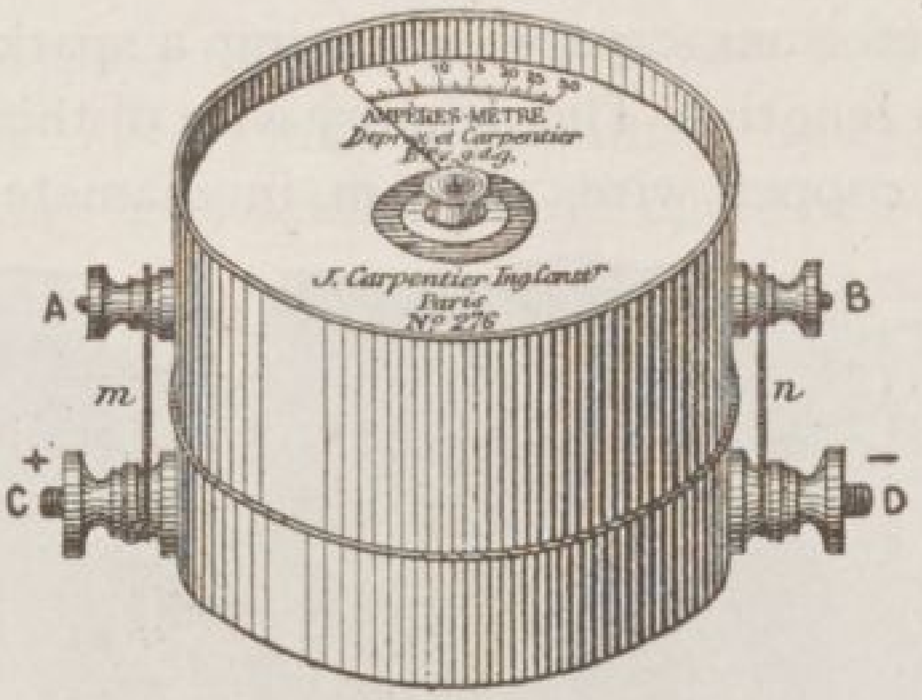
A large inductorium, capable of giving a spark in air of about twenty inches in length. The primary wire of this coil was formed of 403 turns of copper wire, 2·5 mm. in diameter, and having a resistance of ·25 of an ohm. The secondary wire consisted of 102,500 turns of No. 34 copper wire, equal to about thirty-seven miles, and had a resistance of 58,000 ohms. It required a current of about twenty-five ampères in the primary to give a spark twenty inches long. It could be worked with slow or rapid vibrators, which were mounted upon the base or either side of the coil.



Induction Machine (Carpentier).

Voltameters and ampèremeters, of Carpentier and Deprez pattern. These, aside from being as accurate as others, are considerably cheaper.

Electrometer of Mascart.



Ampèremeter (Carpentier.)

Deprez electric motors.

Apparatus, of Melloni, with many accessories, and the Clamond thermopiles, which give with a gas flame an E. M. F. of about one-fiftieth volt per pair.

APPARATUS OF EDELMANN.

The most of the apparatus exhibited by this maker was intended for accurate electrical measurements and original research. Some of the voltameters and ammeters for student's use are cheap, but good. A Wiedemann galvanometer was used in the test house of the Exhibition.

The attention of the committee was called to Edelmann's "Physikalisches Arbeitsstatif" or universal stand with heavy tripod. This is a very neat and convenient laboratory instrument, and is supplied with a great number of clamps and pincers, and attachments or fitting up apparatus in scientific lectures. Edelmann also exhibited quite a collection of reading telescopes, galvanometers, and a very neat model of Wheatstone's bridge, after von Beetz.

APPARATUS OF ELLIOTT BROTHERS, LONDON.

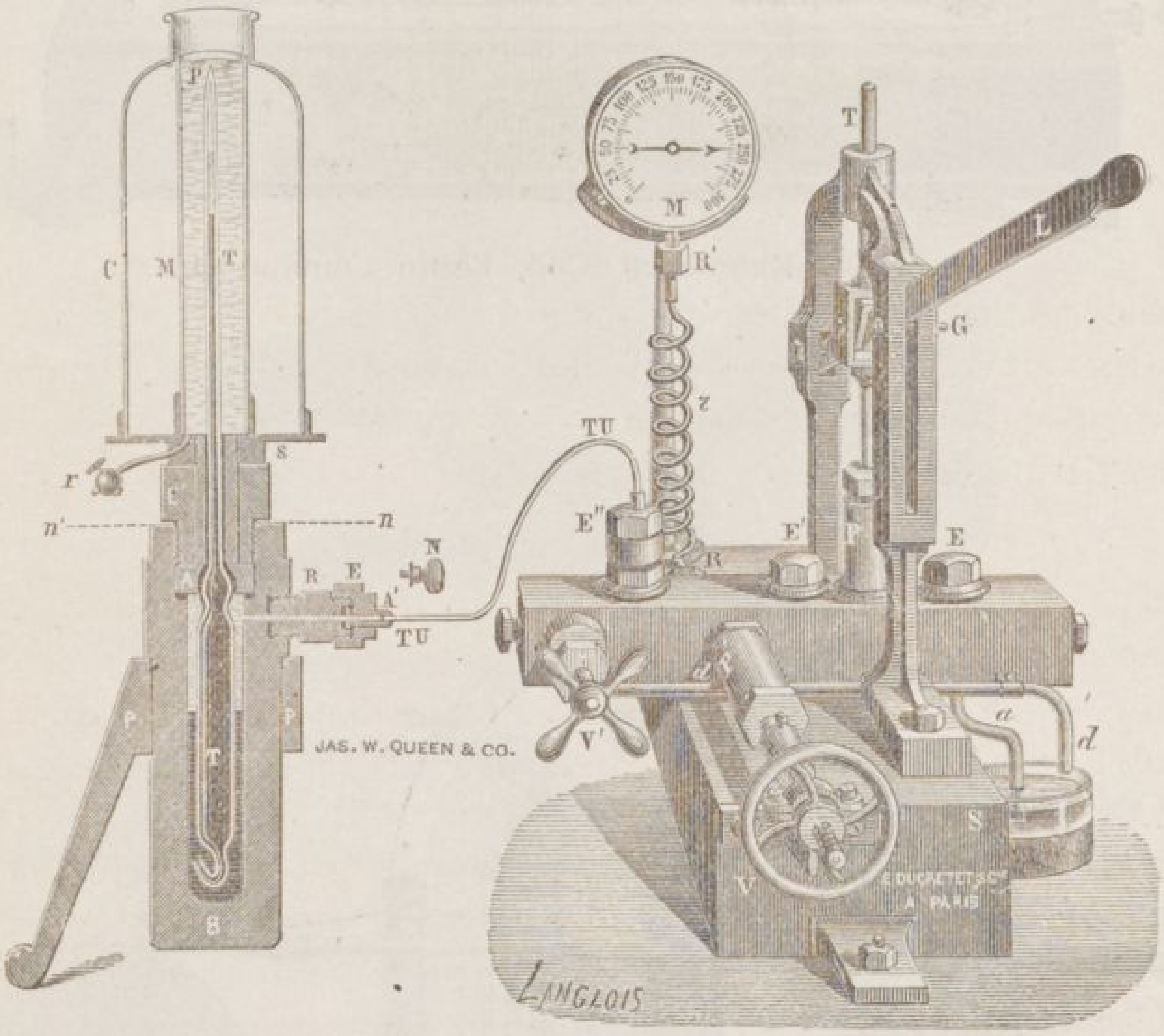
The instruments made by this house are too well known to require specification here. All the apparatus necessary for electrical measurements, Thomson reflecting galvanometer, Wheatstone bridges, Clarke's standard cells, condensers, electrometers, keys, etc., all accurate and well made, were exhibited.

C. J. Simmons also showed some good work in galvanometers, resistance coils and a standard ohm.

The general exhibit of Jas. W. Queen & Co. was of great variety and excellence, and the following list contains only a few of the more novel instruments, and those that deserve a special mention.

CAILLETET'S APPARATUS FOR THE LIQUEFACTION OF GASES.

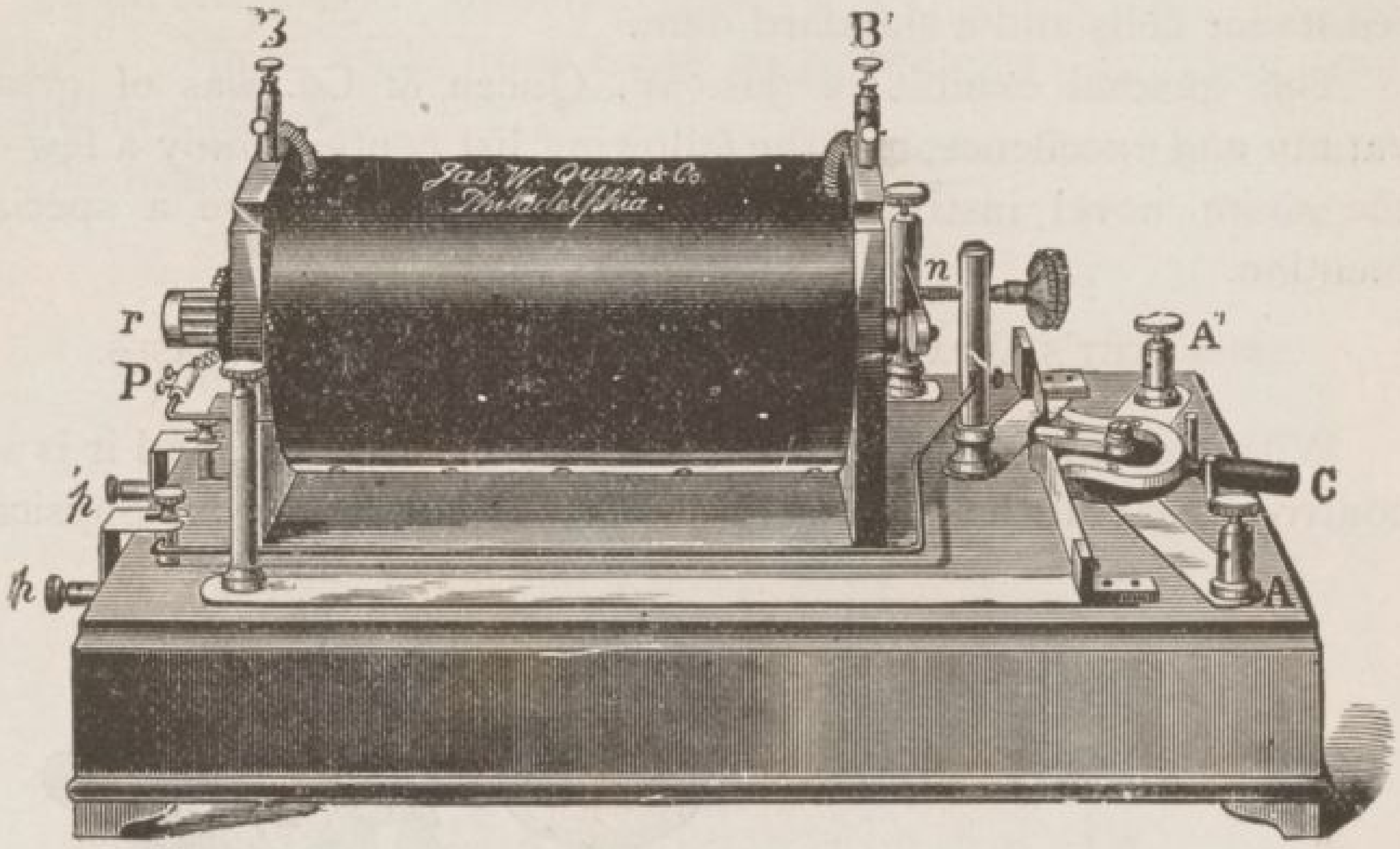
With this apparatus all the gases may be liquefied, and it is so contrived that all the phases of liquefaction and the curious physical changes that take place at the critical point, may be watched without danger. With the pump a pressure of upwards of 300 atmospheres may be produced, and the gauge gives its indications in atmospheres.



Cailletet's Apparatus for the Liquefaction of Gases.

RUHMKORFF COILS.

There were ten different sizes of these instruments shown, varying in length of spark from the one-eighth of an inch to six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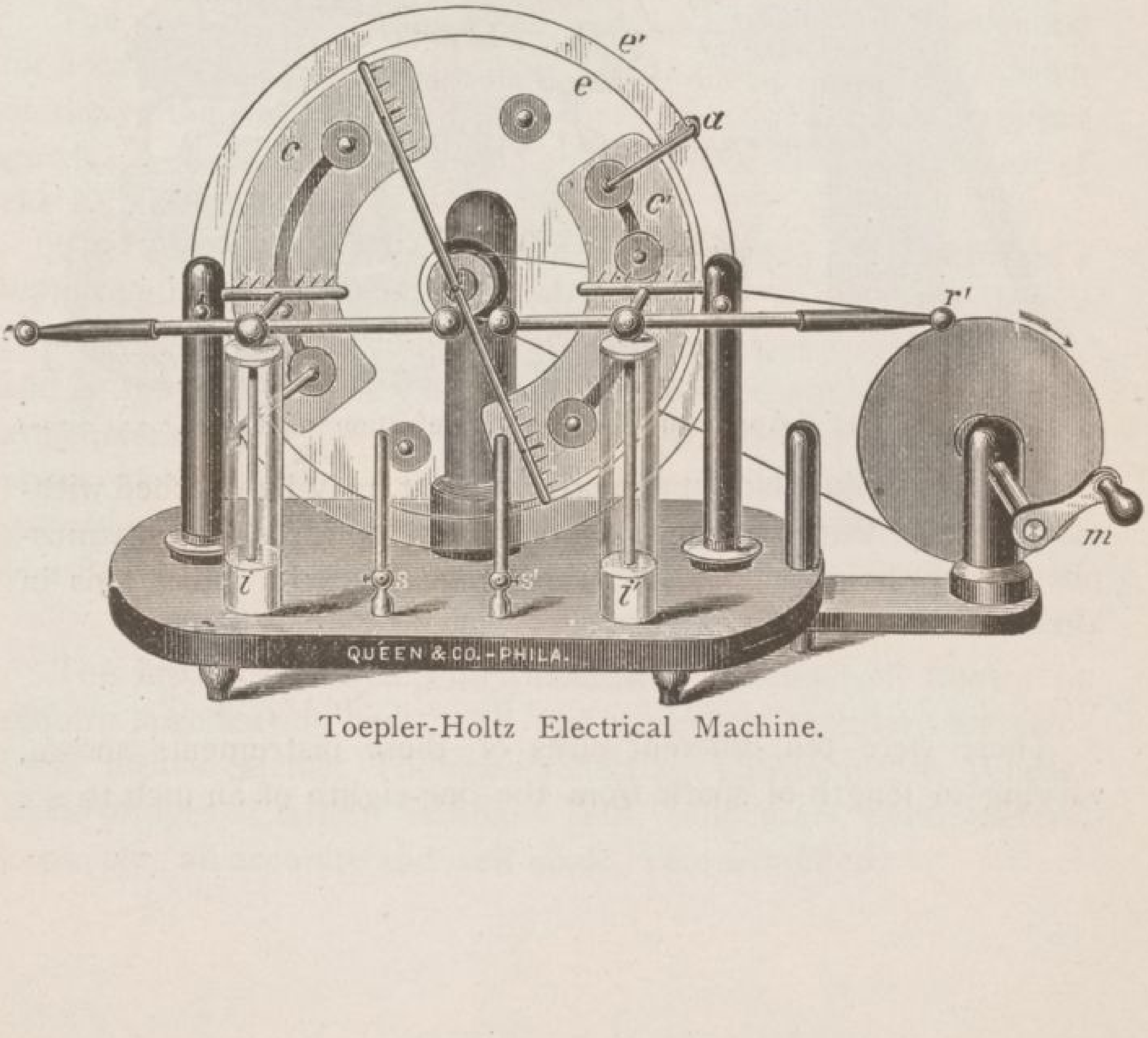
Dissected Ruhmkorff Coil, Bertin Commutator.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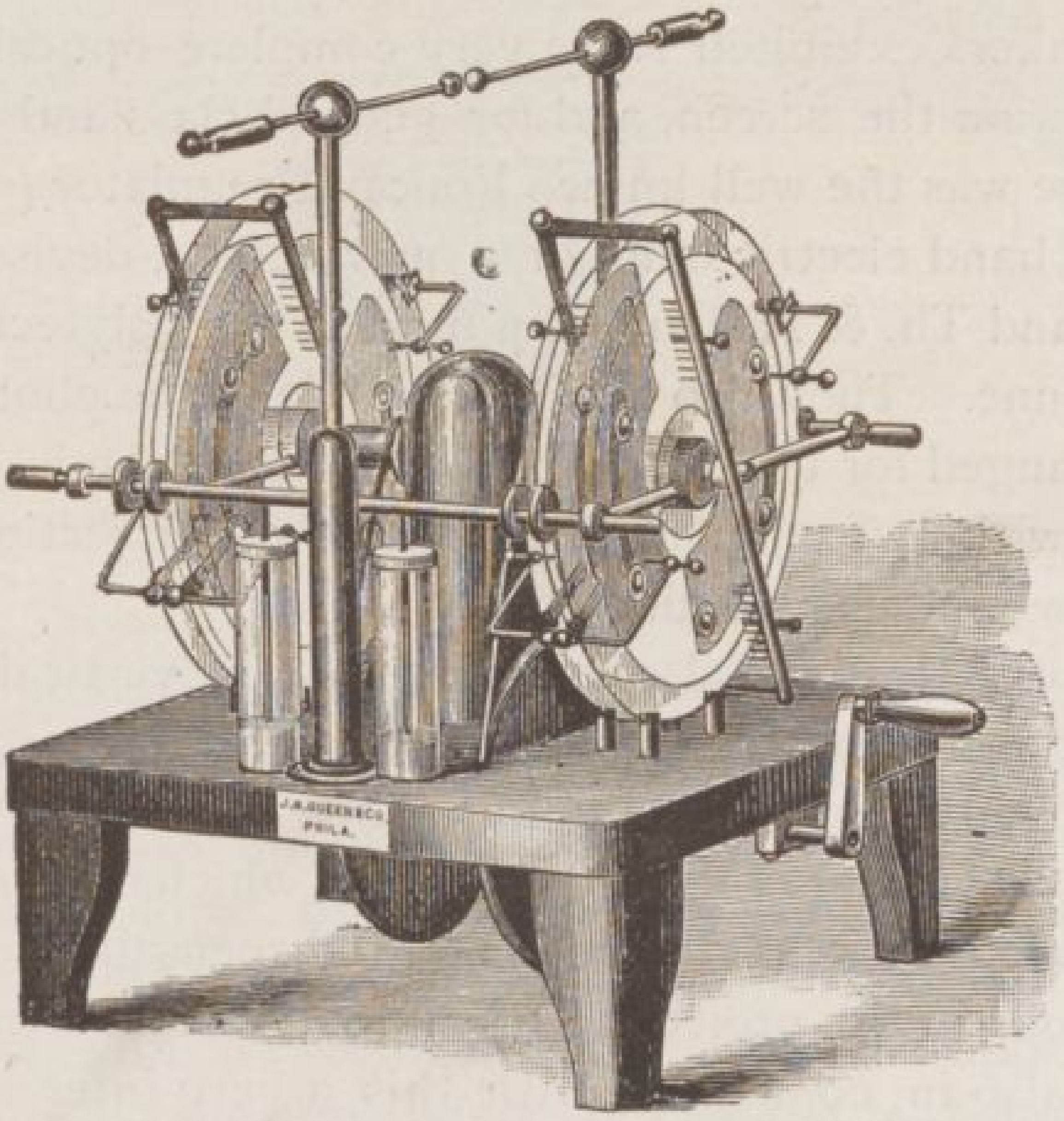
QUEEN & CO.-PHILA.

Toepler-Holtz Electrical Machine.

inches. Two of the larger of these were of special educational value on account of their structure, as they could easily be dissected. Such a form is more valuable than the one commonly sold for purposes of demonstration. The cut represents one of these, which is provided with the Bertin commutator *C*, which enables the operator to be certain of the direction of the current.



Queen's 4-Plate Toepler-Holtz Electrical Machine.

TOEPLER–HOLTZ ELECTRICAL MACHINES.

The Ramsden frictional machine was quite displaced by the invention of the Holtz machine, as the latter is much more efficient, and vastly more compact. But these machines required charging with a catskin or rubber disc, and would not always work. The self-charging machine called the Toepler-Holtz, leaves but little to be desired in that kind of a machine. There were exhibited, both foreign and home-made machines—all of them efficient.

One of these had a revolving plate ten and one-half inches in diameter, and would give a five-inch spark, while the larger plates give a longer and denser spark.

The cut shows one of the American forms of the Toepler-Holtz machines by Queen, finely finished in mahogany and nickel plated. It has an attachment for medical application, and its current may be taken either alternate or direct. These machines are also made with double plates having the same diameter, an arrangement which increases their efficiency. By rotating one of the plates of such a machine, the other may be driven as a motor—a most interesting experiment.

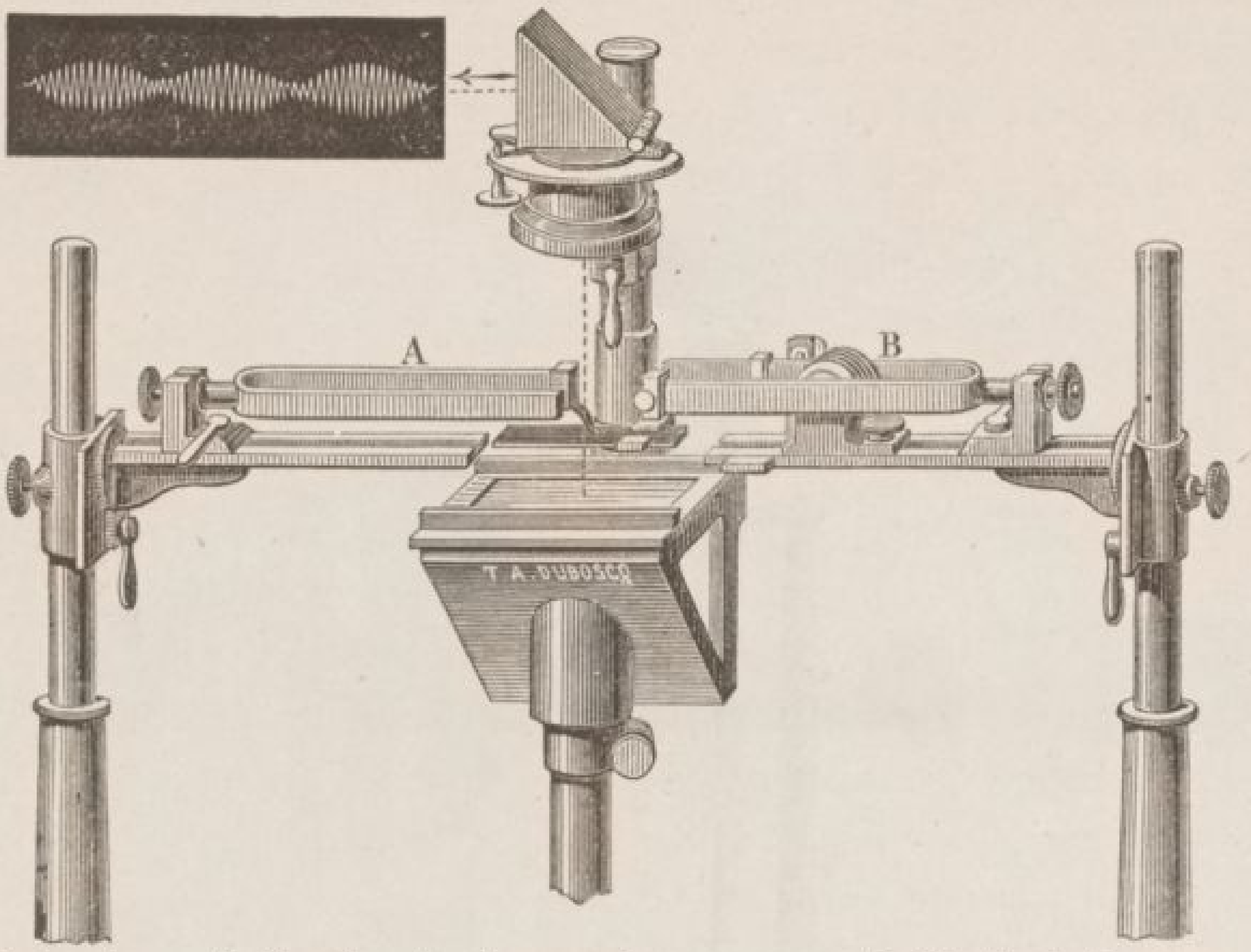
APPARATUS FROM TH. & A. DUBOSCQ, PARIS, EXHIBITED BY JAMES W. QUEEN & CO.

These makers exhibited some very complete optical apparatus for projection on the screen, and for general class and lecture use. Among these was the well known Foucault regulator (see illustration), also a hand electric lamp of a new design, devised by MM. Boudreaux and Th. & A. Duboscq, used at the Polytechnic School of the Sorbonne. They also exhibited a "lanterne photogenique," which is arranged for use with electric light. This is a very fine instrument with two apertures, so that two projections may be thrown on two screens simultaneously.

For use with this was also exhibited a new vertical projection apparatus; perfected by Th. & A. Duboscq, for the projection of two transparent bodies, solid or liquid. This apparatus is furnished with a large condenser of rectangular form, which makes it possible to obtain a very large field, which is an indispensable condition for the inscriptions in the projection of vibratory movements.

There is also in connection with this a very interesting apparatus devised by A. Duboscq, a universal support or electro-diapason, intended to inscribe and show in projection, the vibratory movements. This support on which the diapasons are placed, furnished with stylus and blackened glass, allows of the demonstration in projection of the inscription of intervals; of inscriptions of two vibratory movements, parallel or perpendicular; beats, and the inscription in projection of the optical figures of Lissajous and the experiments of Melde. For the projection of the inscription of sound intervals, with this very interesting apparatus, the two diapasons are placed, one on each support and each furnished with a stylus. The diapasons which have been placed opposite to each others' parallel axes are made to vibrate electrically, the styluses are side by side, and turn in the same way.

There are many other interesting accessories for use with this lantern in connection with electricity: the apparatus of M. Bertin for the electro-magnetic rotation of liquids in hollow magnets, as



Projection of Lissajous's figures by means of Vertical Lantern.

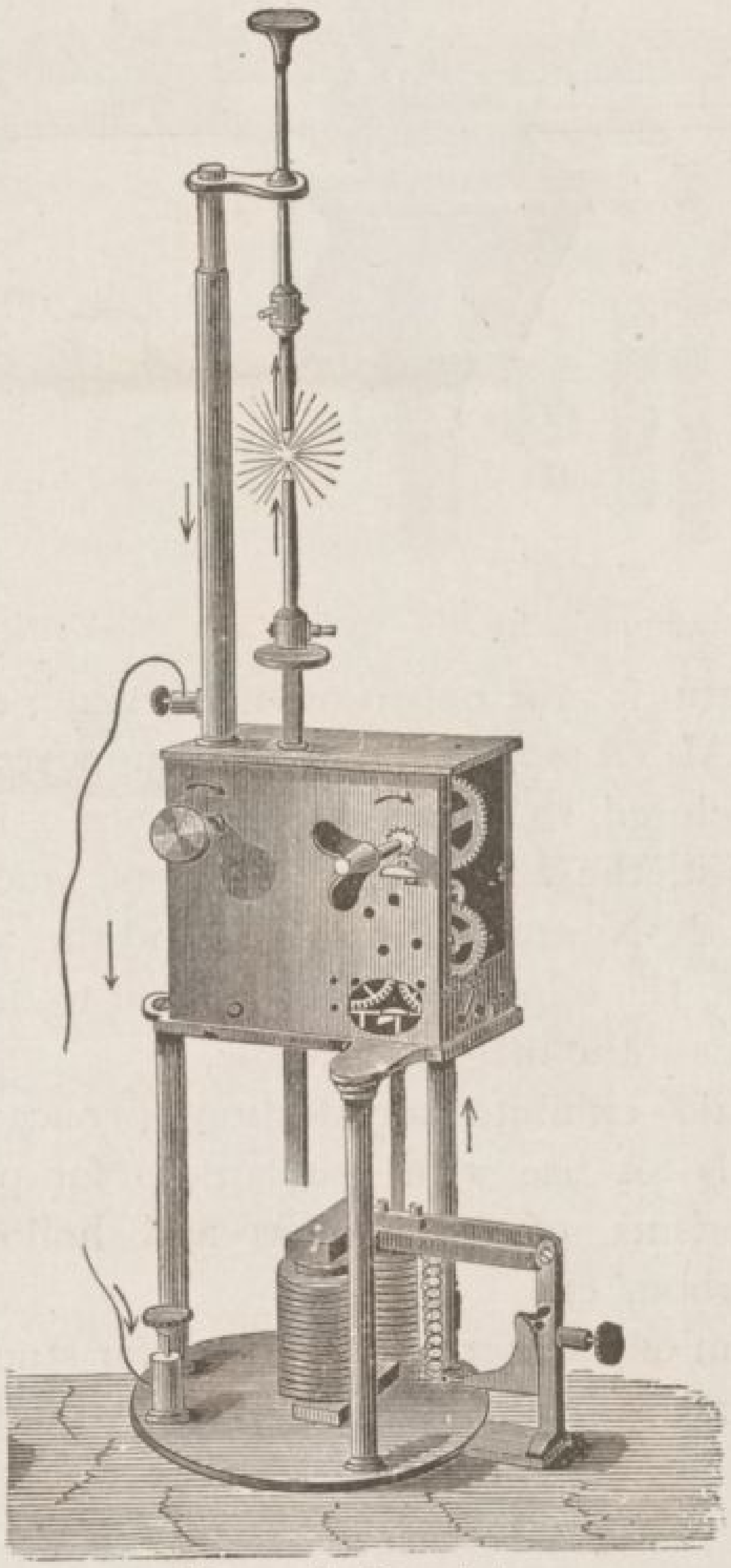
well as the apparatus for the experiments of Arago on the magnetism of rotation. Also a movable arch with support and a series of discs, black and colored, to show the persistance of impressions on the retina, contrast, the admixture of colors, and the complementary colors, with Newton's discs, etc., and the apparatus after Mayer, for showing the experiments of Oersted to demonstrate the lines of currents upon the magnetic needle.

These makers also exhibited a collection of concave and convex lenses upon stands for use with the lantern for projection with electric light; prisms, of solid glass and hollow, containing bi-sulphide of carbon, etc.

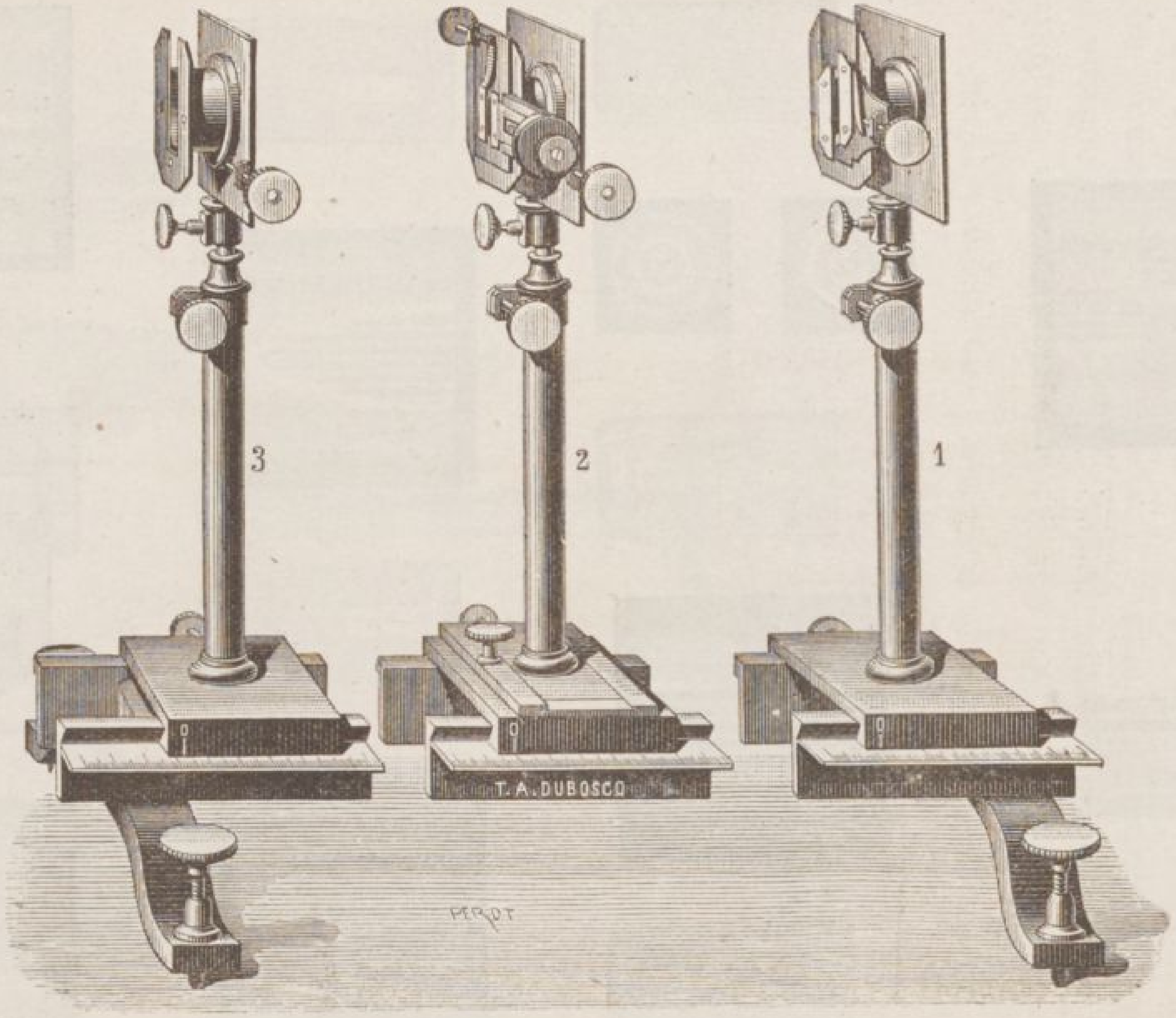
Also a new form of Babinet's goniometer, for student's use. A Norremburg apparatus for the study of polarized light, and a very beautiful spectrometer-goniometer, and a collection of photometers of various kinds, Bougeur, Bunsen and Foucault, etc.

They also exhibited a large diffraction banc. This was a very long and fine one divided into millimetres, and supplied with a very complete set of lenses, slides, prisms, etc., for showing interference, etc., as shown in the figures.

Although few of these instruments are intended for exact measurements, they were of great interest to teachers and lecturers on account of their adaptability for use before an audience, and



Foucault Regulator.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T. A. DUBOSCQ
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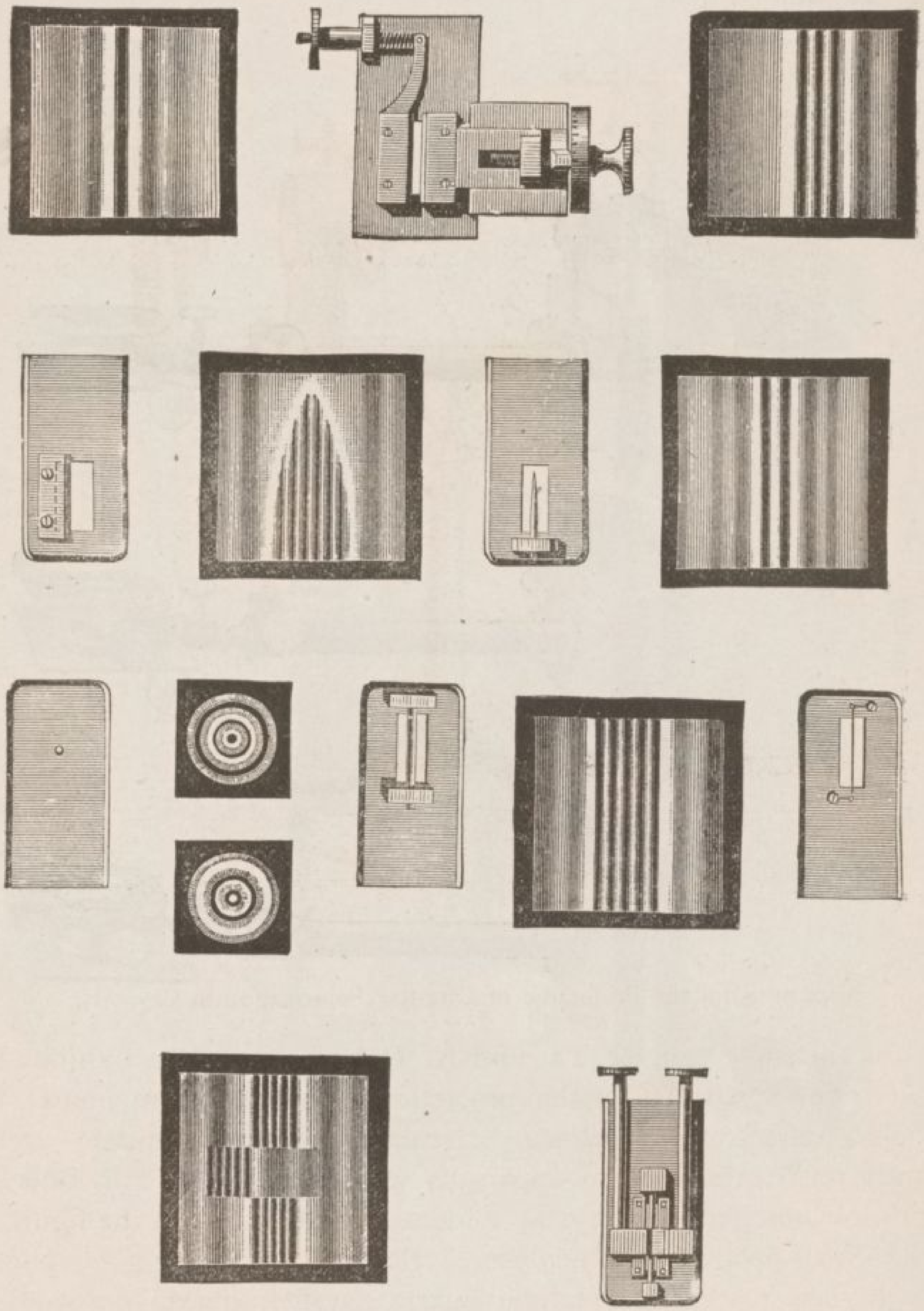
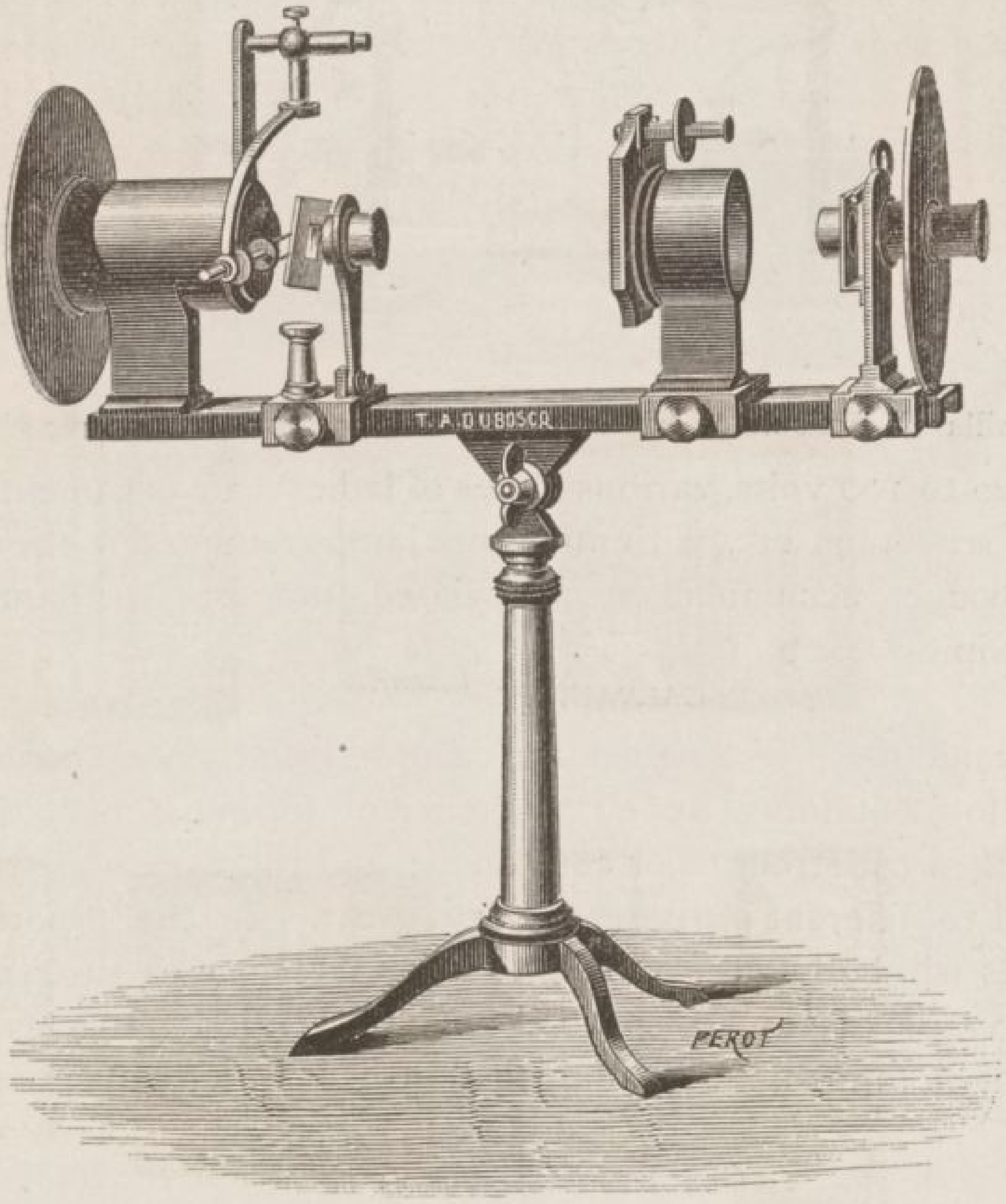
Diffraction Banc,



Interference Phenomena shown by the Diffraction Banc.

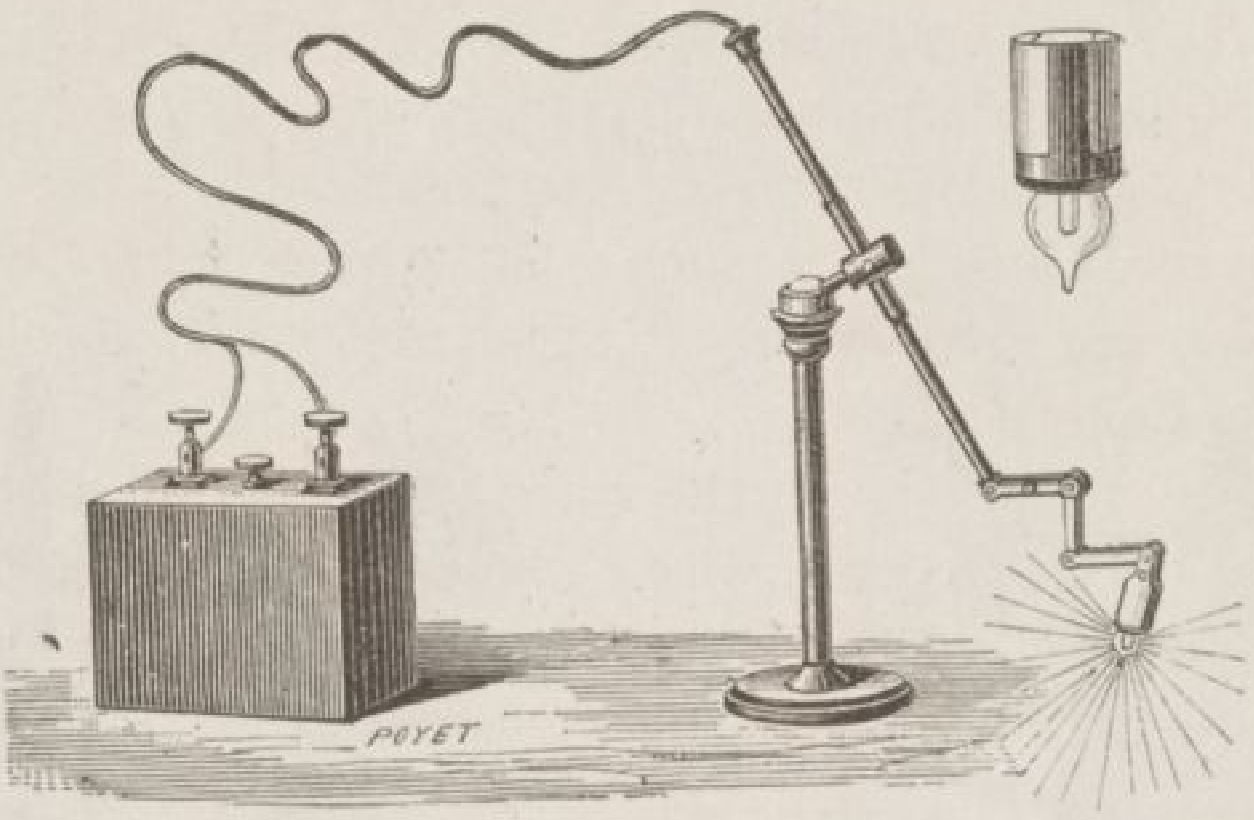
because of the skill which has been used to render them useful for exhibition by means of electric light which is now so much used for scientific work.



Apparatus for the Projection of Circular Polarization in Crystals.

In the collection of Th. and A. Duboscq was also exhibited a very fine apparatus for the projection of all the phenomena of double refraction, rectilinear, circular, elliptic, chromatic and rotary polarization. The apparatus was finely finished in brass, with movable lens and crystal holders, etc., as shown in the figure, with Nicol polarizer and analyser, Delezenne polarizer, glass pile, black glass plates, tourmaline, quartz parallel, quartz perpendicular, one-quarter wave micas, direct-vision prism, compensator and soleil biquartz, rectilinear aperture, microscope, etc., the whole capable of being used with any lantern or *porte lumière*.

L. Aboillard exhibited a fine collection of incandescent lamps

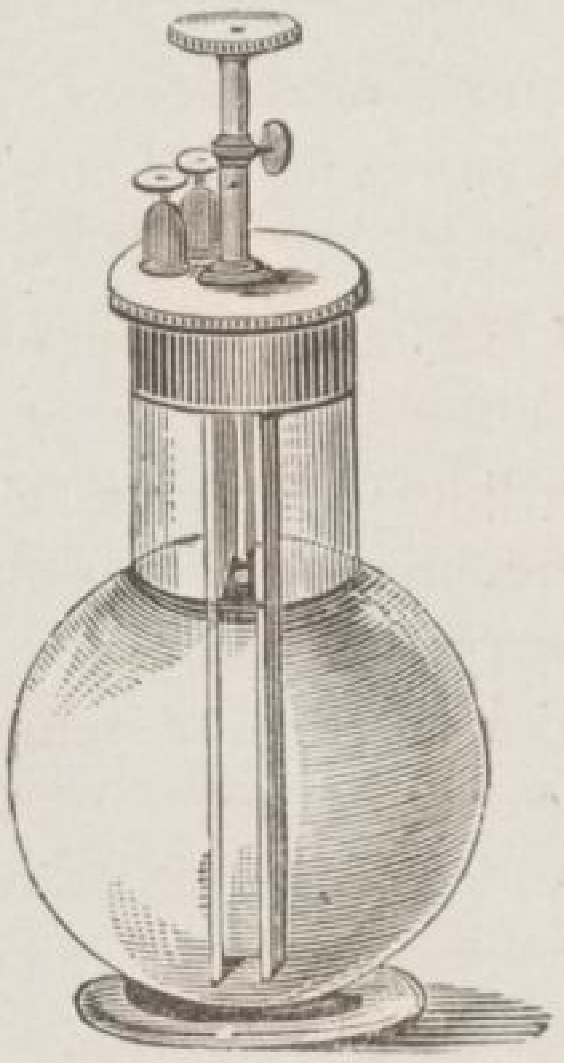


Aboillard's Articulated Electric Lamp Support for Microscopic Use.

from two to 100 volts, various styles of ladies' hair ornaments, butterflies, scarf pins, etc., with miniature lamps mounted in the centre, small pocket accumulators, articulated supports for lamps for microscopic use, etc.

GALVANIC BATTERIES.

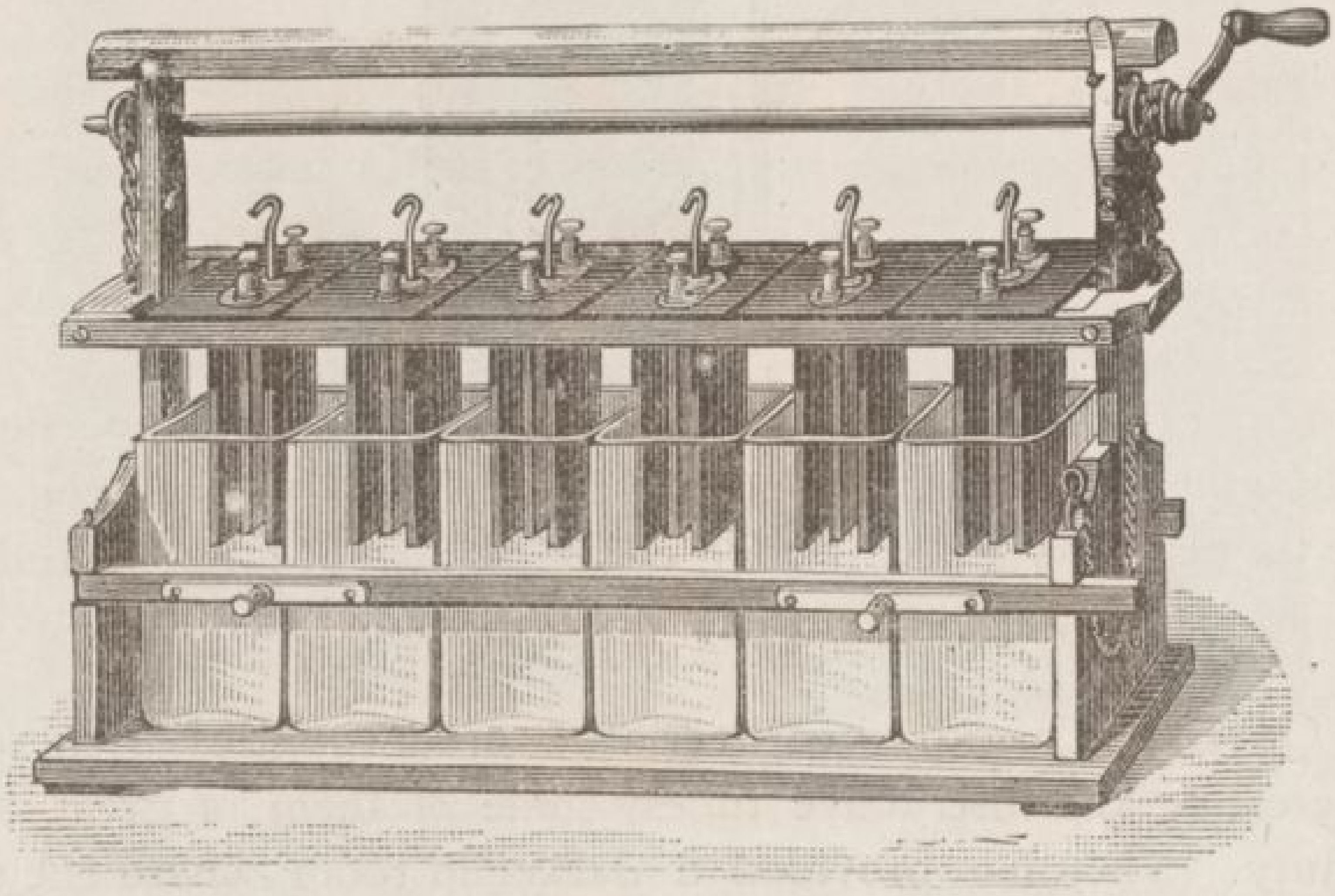
Galvanic batteries are yet the simplest and most convenient means for obtaining an electric current for most purposes not requiring great strength or constancy; and the variety of batteries adapted to different purposes is very great. In the report upon batteries will be found some data for judgment as to their adaptation to various uses. But there are many good batteries which were not examined, and among them are such as the Bunsen, the



Grenet Bichromate Cell.

Grenet and the Grove. Of these, the Grenet, or as it is most generally called the bichromate cell, is one of the best. When freshly set up its electro-motive force is just about two volts, and its internal resistance low. Such a one as is represented in the cut, holding out two litres of liquid will rarely measure over a quarter of an ohm.

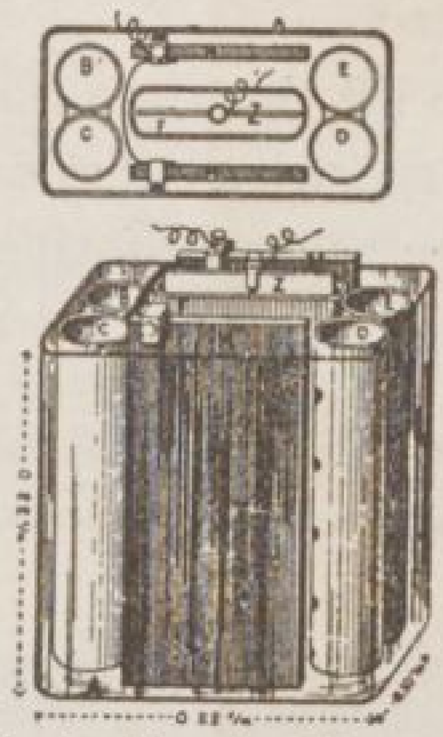
But it is necessary to lift the zincs out of the solution when not in electrical action, as otherwise chemical action goes on and the zinc is dissolved. When several of these zincs are used together, it is exceedingly convenient to have all the zincs lifted out of their solutions at the same time, and Queen & Co. showed a battery of six such cells having a wheel and rachet for lifting out the elements from the liquid when not in use. Such a battery of cells has an electro-motive force of twelve volts, and will yield a current of about ten ampères on short circuit.



Queen's New Plunger Battery.

Such a battery will suffice for most illustrative and teaching purposes, but if incandescent lighting with it is desired, it will need a ten or eleven volt lamp, which will give four or five candle-power.

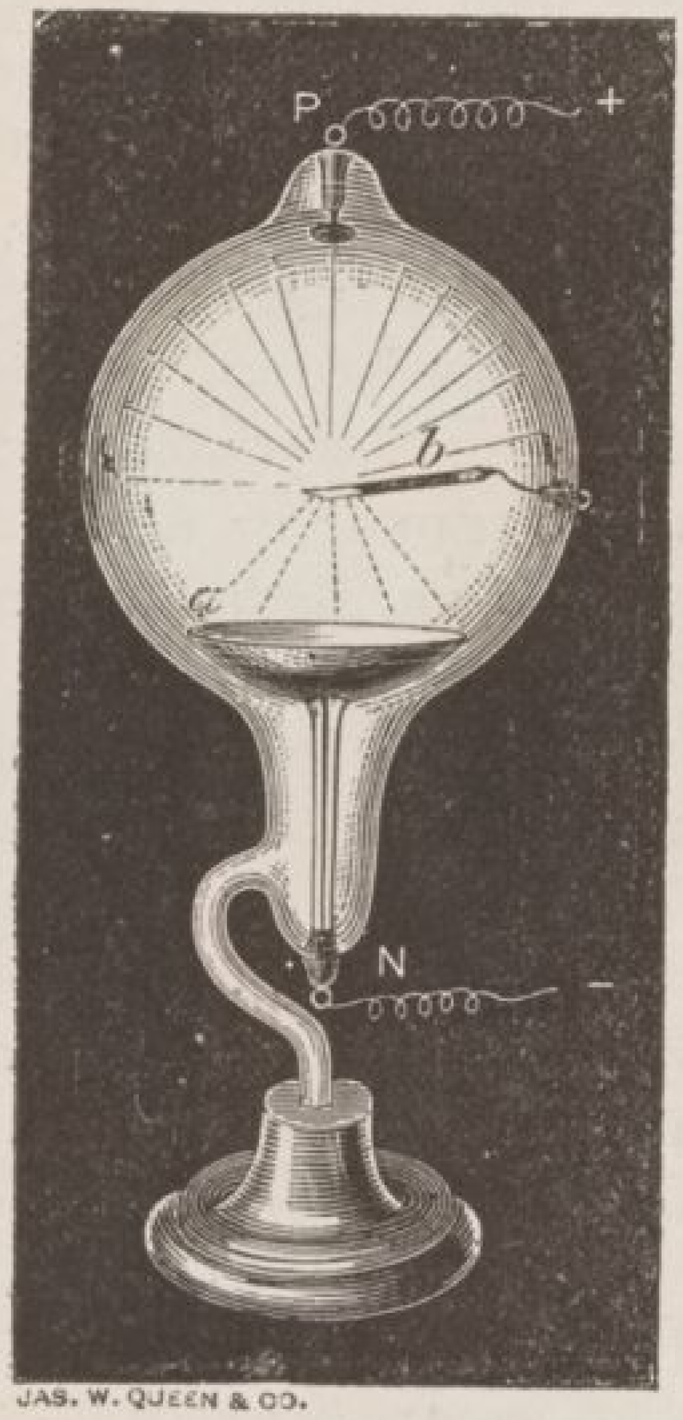
What is known as a Chloris Baudet battery or unpolarizable cell, proved upon test to be a first-class battery cell giving an electro-motive force of 1·87 volts, and with low internal resistance and a remarkable degree of constancy when compared with most other cells. This battery is a two-fluid battery, with the zinc in a solution of an hydrogen-potassium sulphate in an ample porous jar and plates of carbon in the outer jar, which contains a saturated solution of bichromate of potassium and sulphuric acid as is usual in the Grenet cell. If the outer jar be made large enough to permit holding two small porous jars, one to contain strong sulphuric acid, and the other crystals of bichromate of potassium, these will diffuse themselves and maintain the strength of the solution. Thus the battery may give a strong constant current for several days.



Chloris Baudet Battery.

GEISSLER & CROOKES TUBES.

Queen & Co. exhibited over a hundred varieties of these most interesting and instructive tubes, some of them of great size and beauty. They had provided a darkened room, where they could be seen to advantage in the day-time. These tubes are now so well known that no description of them is needed here, but the committee would remark that aside from the great beauty of some of these Crookes tubes when lighted up by molecular bombardment, the tubes may serve for demonstration in every department of physics. The first laws of motion in mechanics, the development of heat by impact, the development of radiant energy by impact, the production of visible motion and of sound by molecular impact, the electrical phenomena of parallel electrical currents, the effect of magnets upon electrical currents, phosphoresence, fluorescence, etc., etc., so that an ingenious teacher might demonstrate nearly every principle in physics with an appropriate set of Geissler & Crookes tubes. The cuts represent some of the most remarkable of these tubes for the development of motion, incandescence, phosphorescence and the shadow.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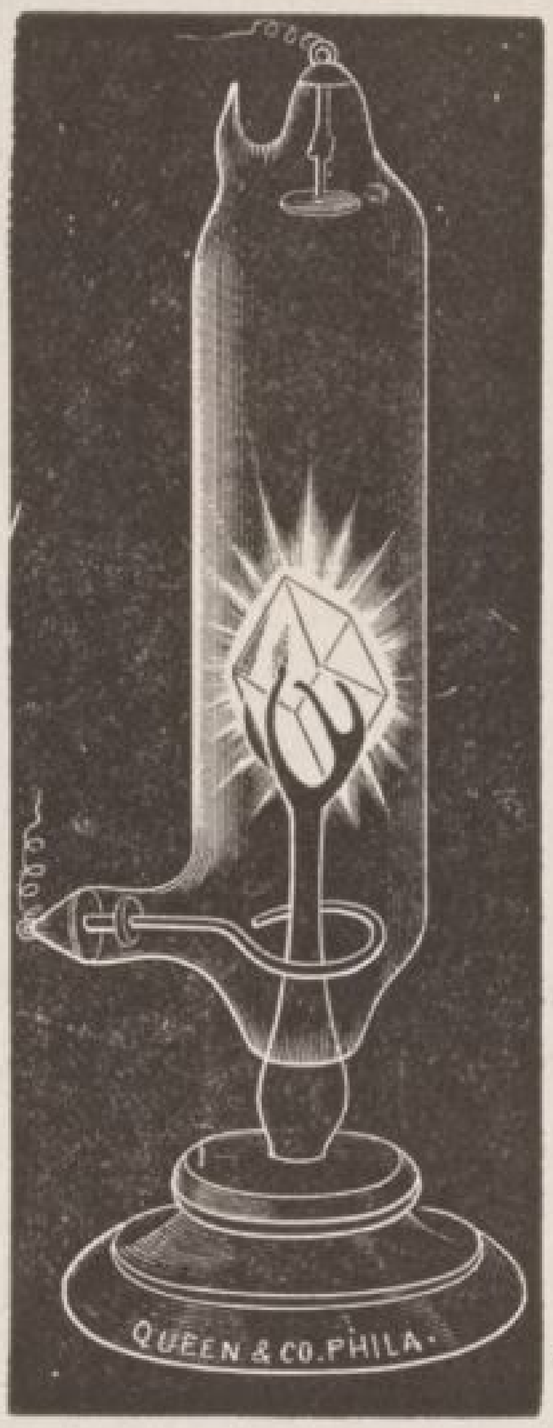
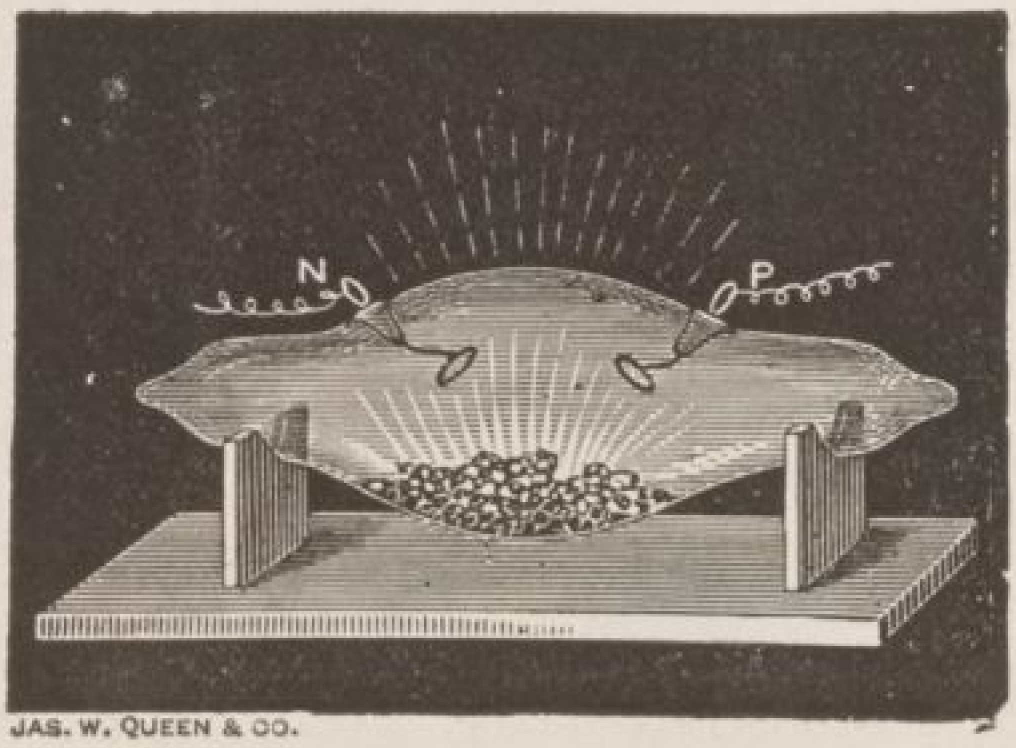
JAS. W. QUEEN & CO.

Crookes' Tube. Showing the
Molecules thrown to a Focus
producing Heat in a piece
of Platinum Foil.


QUEEN & CO. PHILA.

Crookes' Tube. Containing a Crystal of
Iceland Spar.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JAS. W. QUEEN & CO.

Ruby Tube. Containing Shells and Minerals of various kinds.

GENERAL PHYSICAL APPARATUS, NOT ELECTRICAL, EXHIBITED BY JAMES W. QUEEN & CO.

A few of these possessing more than ordinary interest, it is thought best to mention here; not with the idea of making a report on them, but because they were exhibited, attracted the attention of many visitors, and were worthy of attention.

A collection of sections of crystals, quartz lenses and prisms and glass crystal models, by Drs. Steeg and Reuter.

One set in a mahogany case contains 178 sections of crystals and preparations. A quartz lens, 75 mm. in diameter and 1,500 mm. radius. Also a cube of uranium, dydimium and sappharine glass and fluor spar, in a case.

A large exhibit of glass crystal models, beautifully made and arranged, showing accurately the axis of the crystals. There were fifty of these models.

Cathetometers of several sizes and forms. One was particularly well adapted to laboratory work, both physical and chemical. It was one and one-quarter metres high, and is so arranged that it may be used either vertically or horizontally. One of these when tested was found to be as accurate and as convenient to use as some costing three or four times as much.

There were models of telescopes, the galilean, the astronomical and the terrestrial, with the direction of the rays indicated by colored threads which are useful helps to beginners in such studies. Also a similar model of a compound microscope.

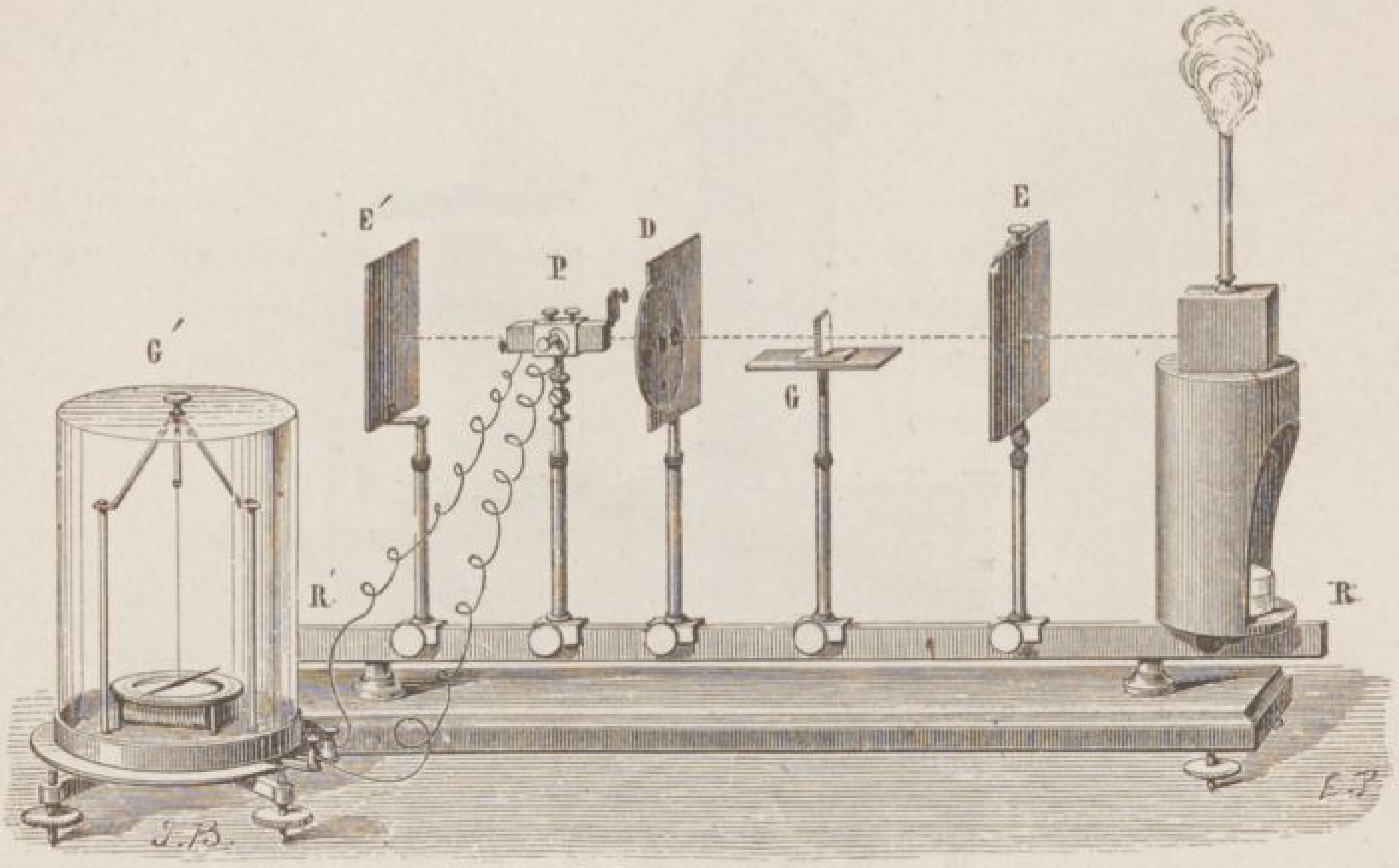
A number of rock salt prisms and lenses, one of the latter being eighty-five mm. in diameter, and thirty collections of gelatine films for selective absorption of colors; the coloring was said to be with chemically pure substances. In each of these sets there were thirty films forming a very convenient and tolerably complete collection.

MELLONI'S APPARATUS.

A finely constructed piece of apparatus for delicate experiments in heat, with between thirty and forty accessories, was shown. It was manufactured by Carpentier, of Paris, and was contained in a very neat and compact case for safe keeping and transportation.

OPTICAL BANC.

There were two of these pieces of optical apparatus with numerous accessories. One of them made of mahogany two metres long



Melloni Apparatus.

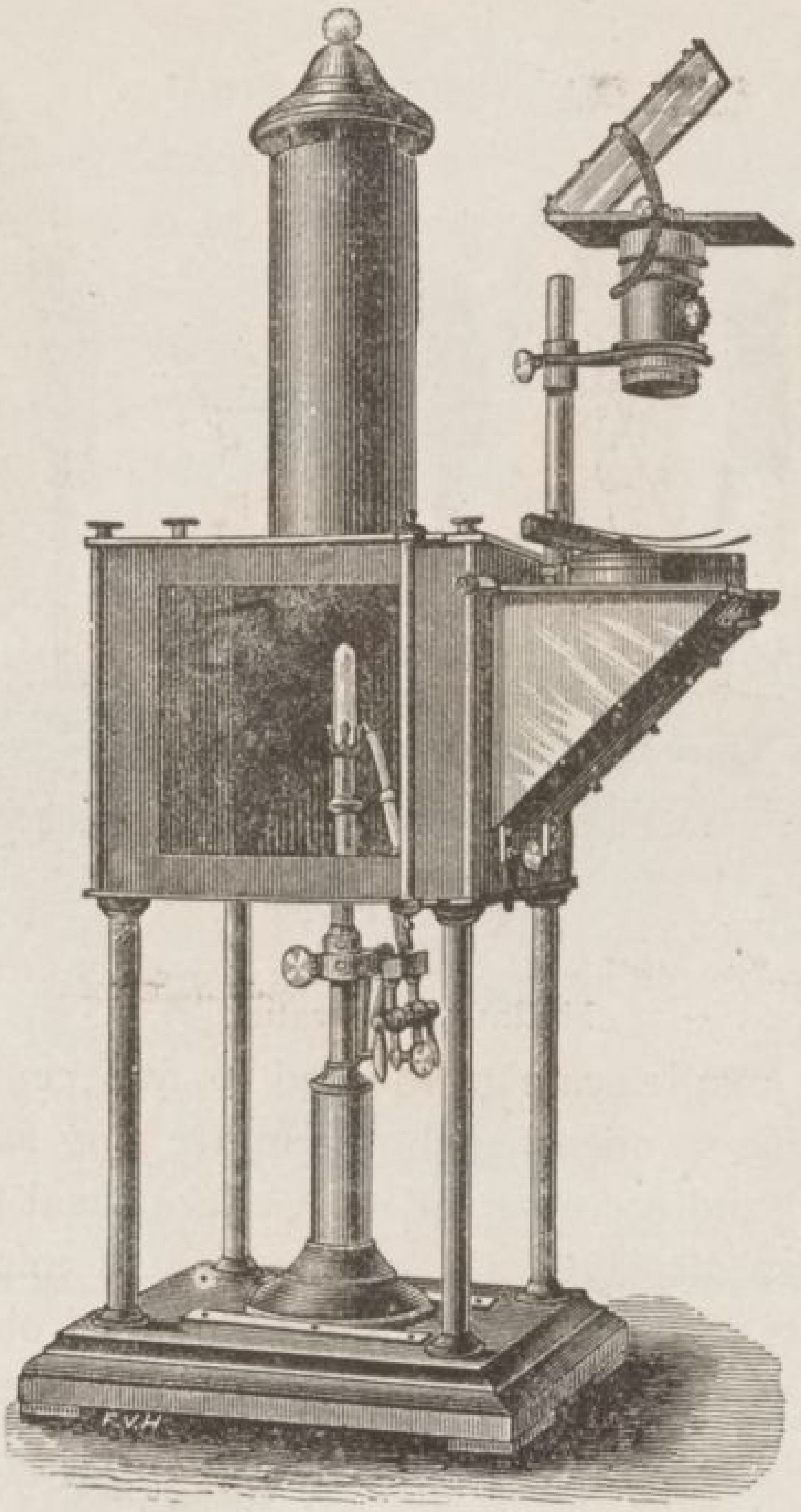
and a veneered maple scale graduated to five centimetres. The other one a simple wooden bench one metre long with eight slides, sufficiently good and accurate for most educational purposes.

There was also displayed a fine collection of microscopic apparatus of the finest workmanship, the collection of objects for polariscopic study was very extensive, and many of the objects themselves very beautiful and deserving of mention.

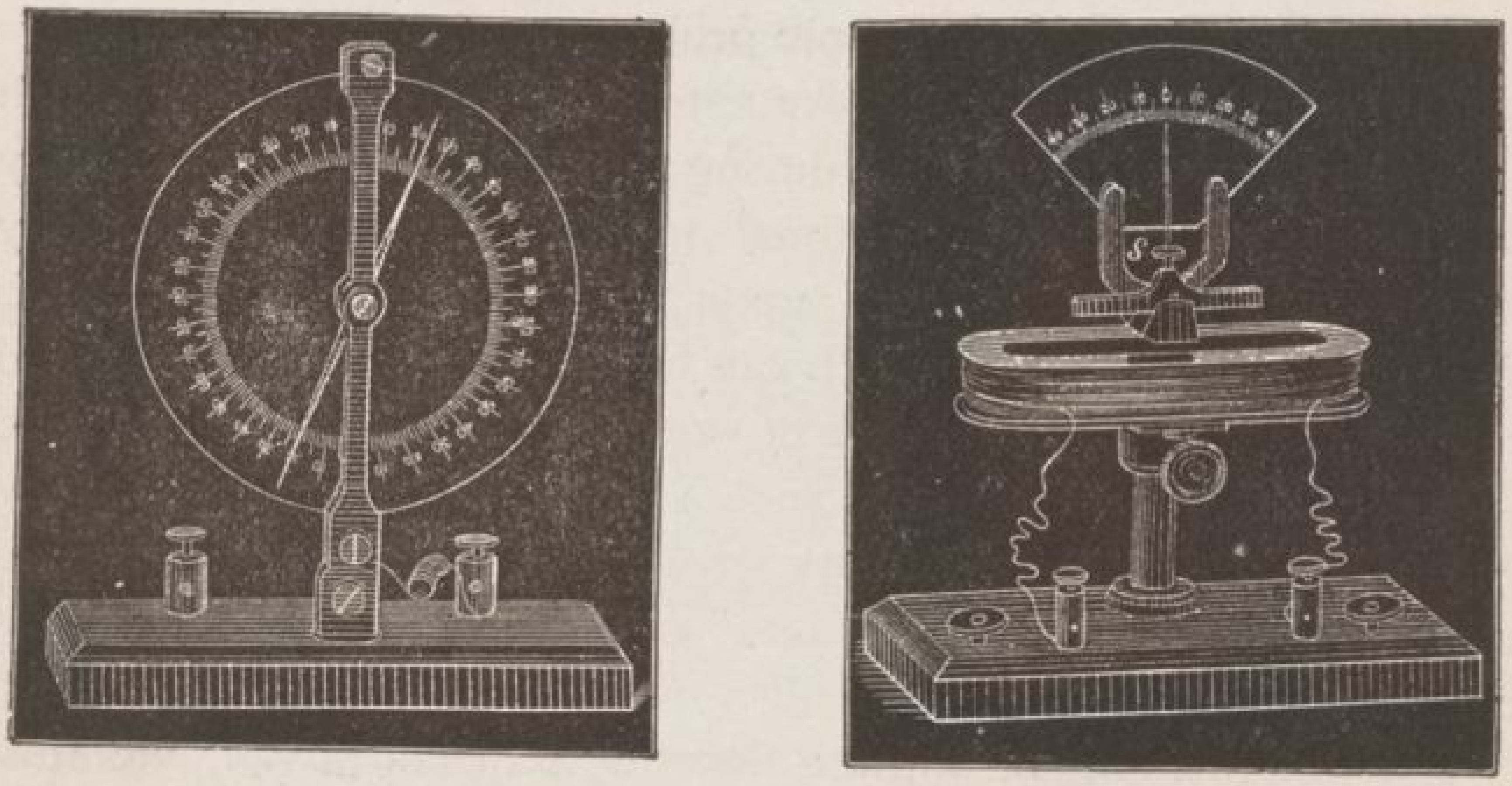
APPARATUS FOR PROJECTION.

A lantern adapted for the projection of all sorts of physical phenomena, as well as the simple projection of transparent photographs was shown. The rivalry among different makers of such pieces has served to develop during the past ten years this very useful adjunct to an educational institution, until almost any phenomenon may be shown upon the screen; and what is really needed is a lantern which can be easily and quickly changed and adapted to different classes of work. Considerable experience has led to the conclusion that such a lantern as was exhibited by Queen & Co. is adapted to as great a variety of work and is manipulated as easily as any one with which the committee is acquainted.

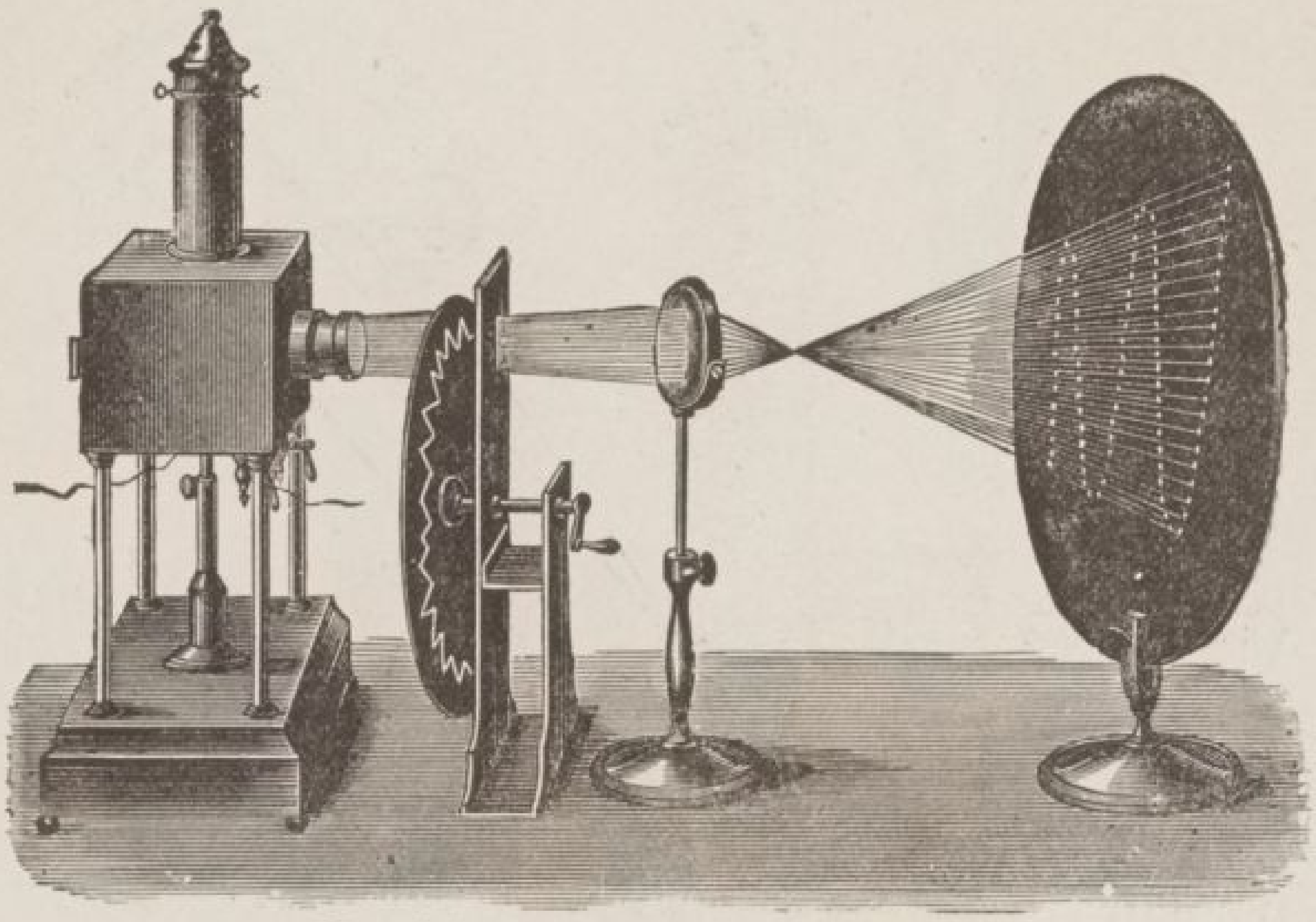
The application of minute incandescent lamps for the illumination of the microscope, has recently attracted considerable



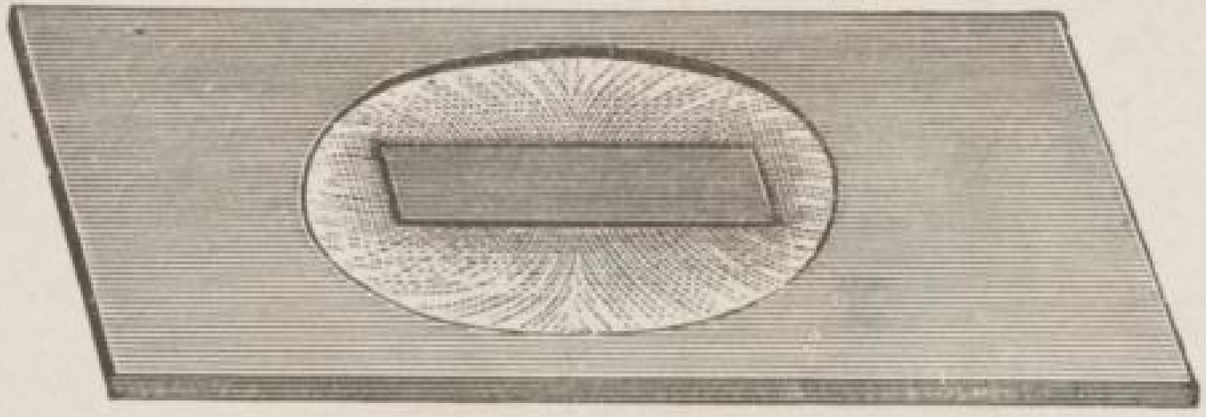
Projector, with Vertical Attachment for Chemical and Physical Experiments.



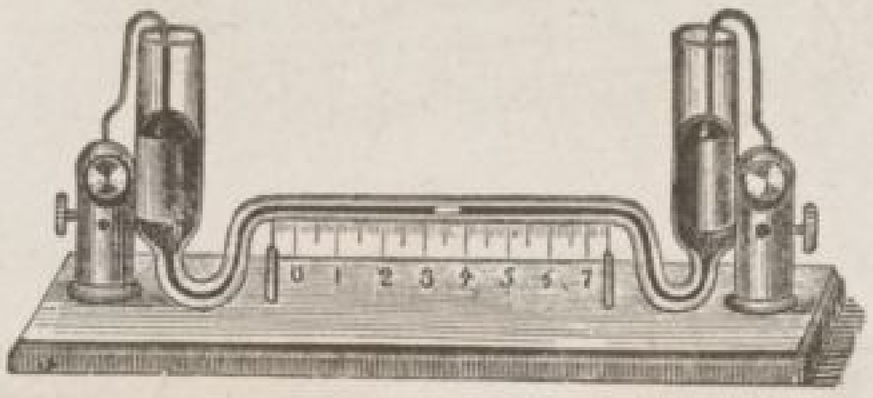
Galvanometers for Projection.



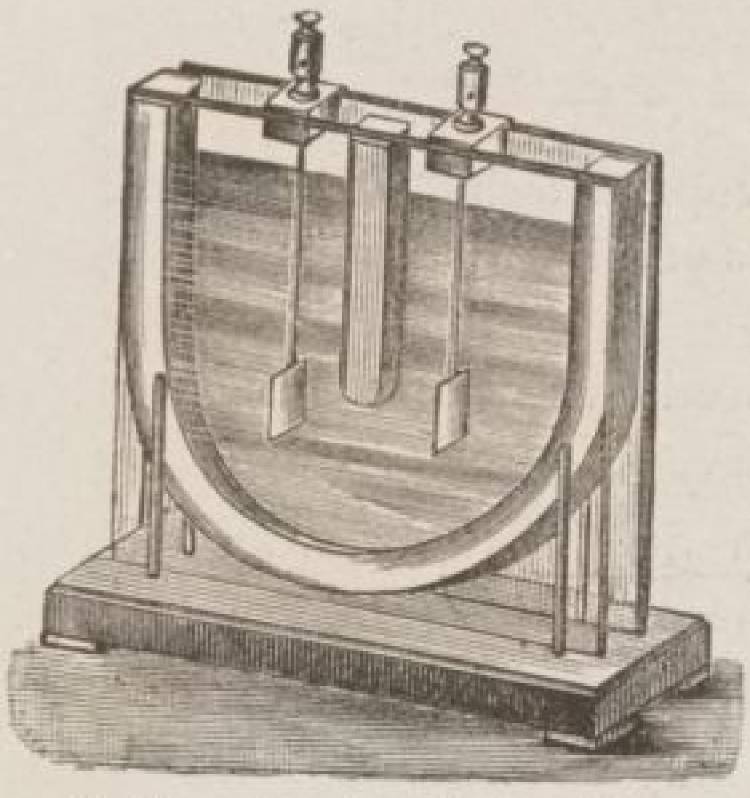
Koenig's Wave Motion Apparatus.



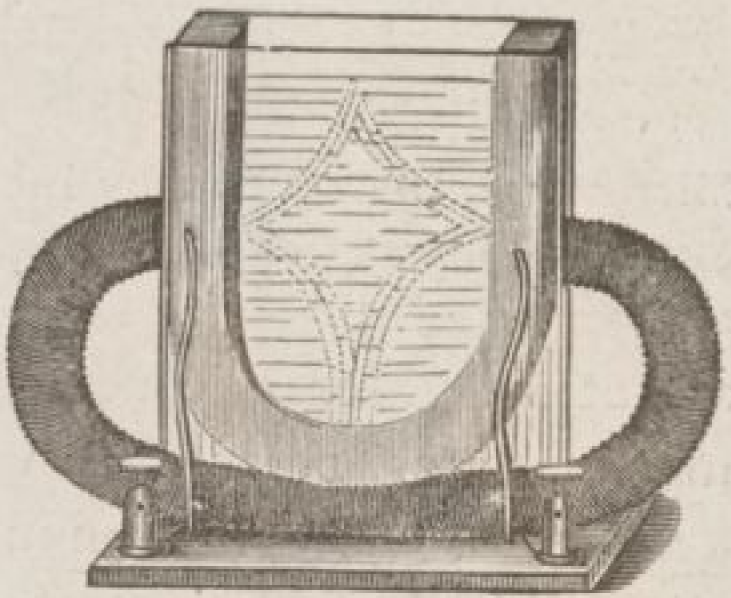
Slide Showing the Lines of Force.



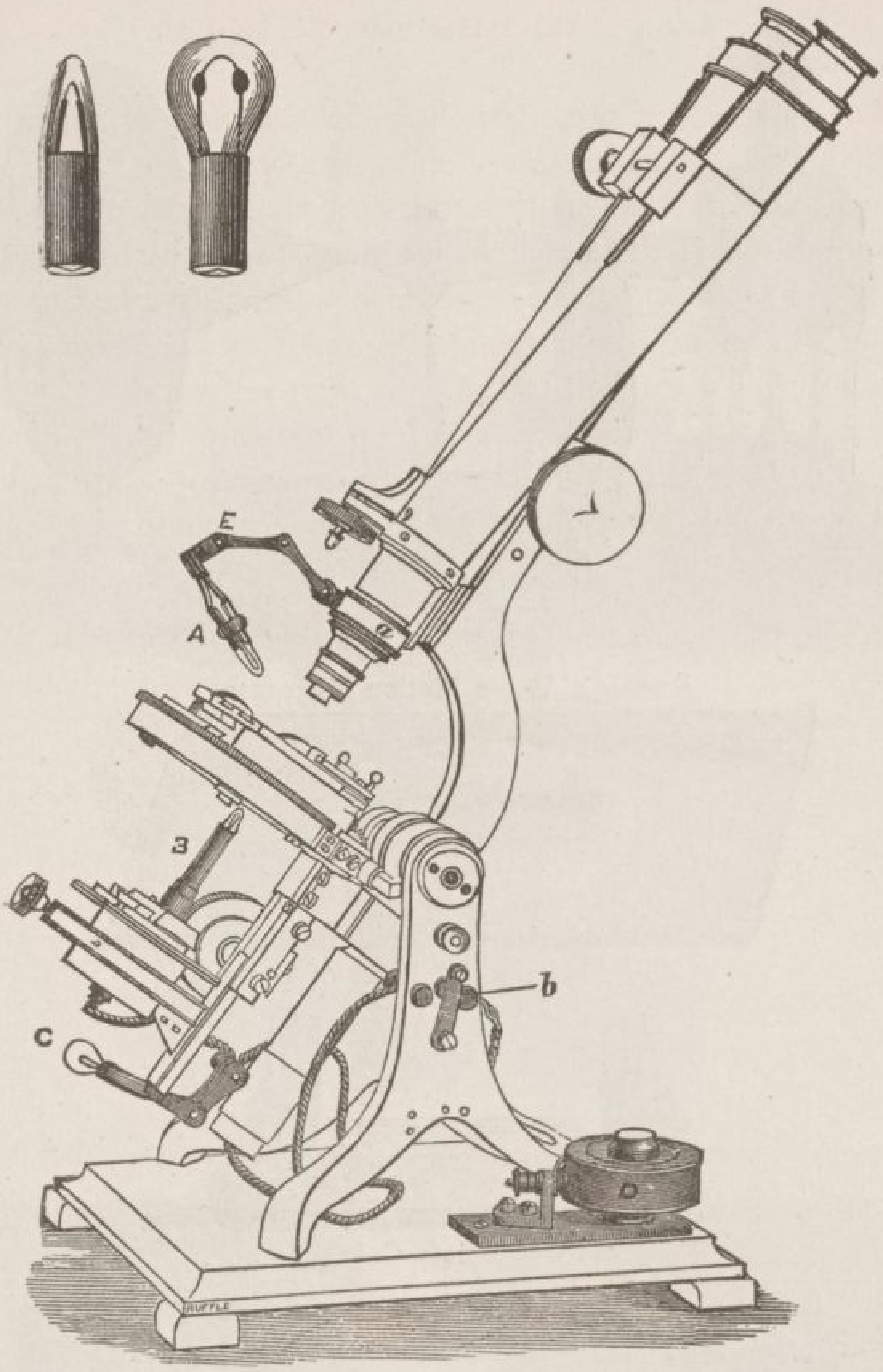
Weinhold's Capillary Galvanoscope.



Voltameter for Projection.



Electro-Magnet for showing lines of Force by means of Iron Filings in a Tank of Glycerine.



Microscope, Illuminated by Incandescent Lamps, showing (for convenience of illustration) several different Forms of Mountings at once.

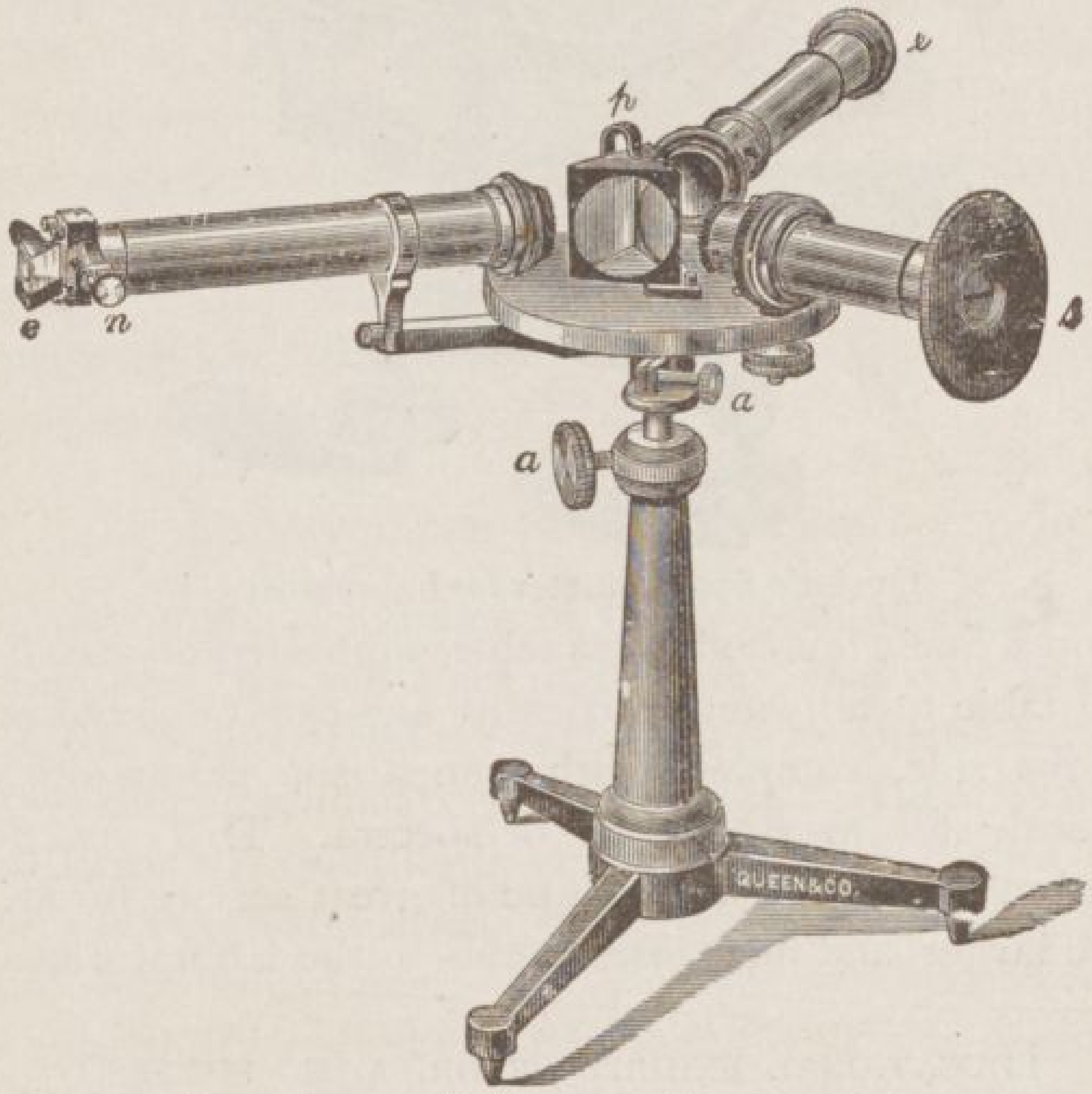
attention. Messrs. Queen & Co. exhibited five microscopes, binocular and monocular, with various forms of mounting.

One of these is a mounting which fits in the holder of the mirror (the latter being removable) below the sub-stage condenser; another is a separate stand, so arranged with universal movements, that opaque and transparent objects may be lighted with equal ease. A modification of the latter form fits into the stage forceps hole in the stage.

A form sometimes preferred is where the lamp is mounted to fit in the sub-stage, immediately below the object.

A resistance coil, specially arranged for use with these lamps, was also exhibited. The current is obtained from bichromate batteries, and secondary batteries are also admirably adapted where they can conveniently be charged. A small dynamo machine has very recently been applied to light the lamps direct.

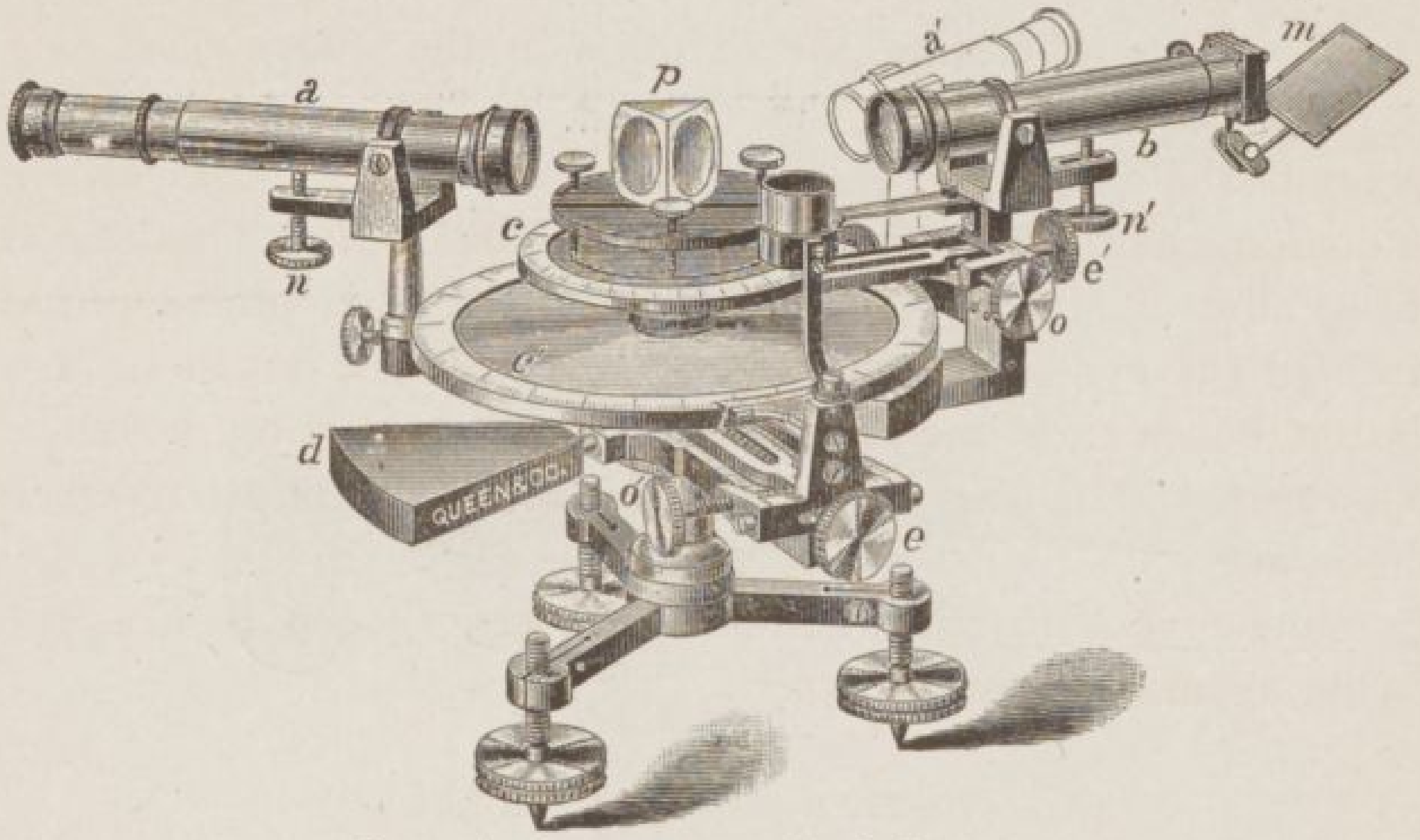
Queen & Co. also exhibited a new spectroscope and goniometer combined. This instrument was specially worthy of attention on account of its excellence of design and workmanship, and reasonable price. It is supplied with two graduated circles of silver, respectively ninety-five and 105 mm. in diameter. It has a micrometer and vernier, each reading to five minutes. The telescopes are properly balanced to give ease of motion and prevent wear, and are provided with both vertical and horizontal adjustments, while an extra arm permits the telescope to be reversed for use with a grating. The prism stage rotates independent of the circles below, and can be adjusted by means of levelling screws to any



Queen's new Laboratory Spectroscope.

position desirable for either grating or prism. A small heliostat on an universal joint is attached to the slit, thus avoiding the necessity of an extra mirror.

They also exhibited a new laboratory spectroscope for teacher's and student's use, furnished with a flint glass prism *p*, thirty-three mm. high, improved slit, with micrometer screw *n*, adjustable telescope *l*, by means of clamping screw *a*, the telescope has 7 mm. aperature, 147 mm. focus. The prism and telescopes are mounted on a finely finished brass table, supported on a neat tripod stand, the table is adjusted vertically, and can be fixed by a set screw at the side, complete with comparison prism and photographed scale for measurement of spectra. This spectroscope supplies a long-felt want, and will be of great service for student's use to save larger and finer instruments in the laboratories of universities.



Queen's Spectrometer for Laboratory.

EDUCATIONAL EXHIBIT OF DR. A. E. FOOTE.

This exhibit consisted of a collection of crystals and massive specimens of minerals. The specimens were of the finest sort, and many of them unique. There were collections suitable for instruction in mineralogy and geology, with huge specimens of crystalline masses of quartz, agates, flour spar, amazon stone, beryl, etc.

Henry Whitall exhibited his well known heliotellus and planisphere both efficient as astronomical illustrations, and much used during the past fifteen or twenty years.

Respectfully submitted, A. E. Dolbear,
Chairman Section XXIX.

SECTION XIII. APPARATUS FOR HIGH ELECTRO-MOTIVE FORCE. CLASS 2. ELECTRO-STATIC INDUCTION MACHINES, INDUCTION COILS, ETC.

The Committee of the Board of Examiners, to whom was deputed the duty of noting the exhibits in the above class, beg leave to report as follows:

None of the exhibits in this class were entered for competitive examination, they were mainly educational instruments, contained in the exhibit of Messrs. James W. Queen & Co., philosophical instrument makers, of Philadelphia. The committee has thought it advisable, however, to mention briefly some interesting novelties which were found in other exhibits, and which have not yet received public notice

Commencing with the exhibit of Messrs. Queen & Co., the following apparatus may be noted.

(A.) TOEPLER–HOLTZ MACHINES.

There were quite a number of these instruments of different sizes, having one, two and four plates each, the revolving plates varying in size from twenty-six centimetres to ninety centimetres, and having simple self-charging appliances. These instruments worked satisfactorily, yielding a torrent of electric flashes with an expenditure of very little labor. They were conspicuous for their fine finish, nice adjustment, and perfect workmanship. Their immense superiority over the old frictional electrical machines, or the earlier forms of the Holtz machine, has caused them to supplant these entirely. It may be said that they mark an era of progress in the improvement of electro-static induction machines as remarkable in this field of research as has been achieved by the dynamo-electric machine in its sphere.

While the electro-static induction machine cannot compare with the induction coil in its perfect reliability of action in all weather and under all conditions, the improvements noted in its construction have materially enlarged its usefulness in various directions.

(B.) INDUCTION COILS.

A number of coils, both of Messrs. Queen & Co.'s manufacture and imported from M. Ruhmkorff, were shown, varying from miniature size, giving sparks of thirty millimetres, up to instruments giving sparks thirty centimetres long. Some of these machines were provided with the Deprez automatic break, and others with the Foucault interrupter. Some were wound in sections and others were so constructed that they might be taken apart without injury, and the connections exposed to view for purposes of study.

All of these instruments were finished in the best manner, and exhibited a thoroughness of workmanship as well as ingenuity of arrangement, which is highly creditable to the manufacturers.

(C.) GEISSLER TUBES.

These are glass tubes of more or less intricate construction, (sealed at each end and having terminal wires of platinum) from which the air, or other gas, has been exhausted until the pressure does not exceed half a millimetre of mercury. They are designed to exhibit the well known and beautiful phenomena of electric discharge in rarefied gases. In addition to the ordinary forms of Geissler tubes, there were several novel ones of interest. The fluorescent and phosphorescent tubes exhibited were remarkable for their brilliancy. In addition to the above, there were a number of Plucker's spectrum tubes, containing traces of various gases, elements and compounds, yielding brilliant spectra when illuminated by the discharge from an induction coil or Holtz machine, and examined by means of a spectroscope.

The so-called "end on" spectrum tubes are especially valuable in spectroscopic research; from their construction it is possible to obtain the full value of the illumination through the *whole length of the tube* instead of transversely, thus giving vastly more light than the ordinary spectrum tubes, and yielding more brilliant lines.

(D.) CROOKES' TUBES.

It is probable that nothing in the exhibition excited more interest than the exhibit of the magnificent tubes designed by Professor Crookes, to illustrate the properties of so-called "radiant matter." Many of these tubes were four times the size of those used by Professor Crookes in his remarkable address before the British Association, in 1878.

They differ from ordinary Geissler tubes in the more complete exhaustion of the air (not over $\frac{1}{1,000,000}$ of an atmosphere remaining) and from the fact that the ordinary effects of Geissler tubes are absent, while a whole new series of remarkable phenomena appear. It is upon the evidence afforded by the peculiar behavior of the radiant matter in these tubes, when under electrical excitement, that Professor Crookes rests his claim to have revealed matter in a state as far removed from gas as gas is from liquid, or liquid from solid, and he called this supposed new condition the "Fourth State of Matter."

The exhibit comprised all of the forms of apparatus first used by Professor Crookes, as well as some tubes of quite recent device. Messrs. Queen & Co. fitted up a small apartment where these tubes were exhibited to a few people each evening. This firm deserves creditable mention for its enterprise in procuring so large and valuable an exhibit of fine apparatus of foreign and domestic manufacture.

The remarkable discoveries of Professor Crookes have been so fully described in the scientific journals that a detailed notice has not been deemed necessary in this report.

EDISON'S TRI-POLAR INCANDESCENT LAMP.

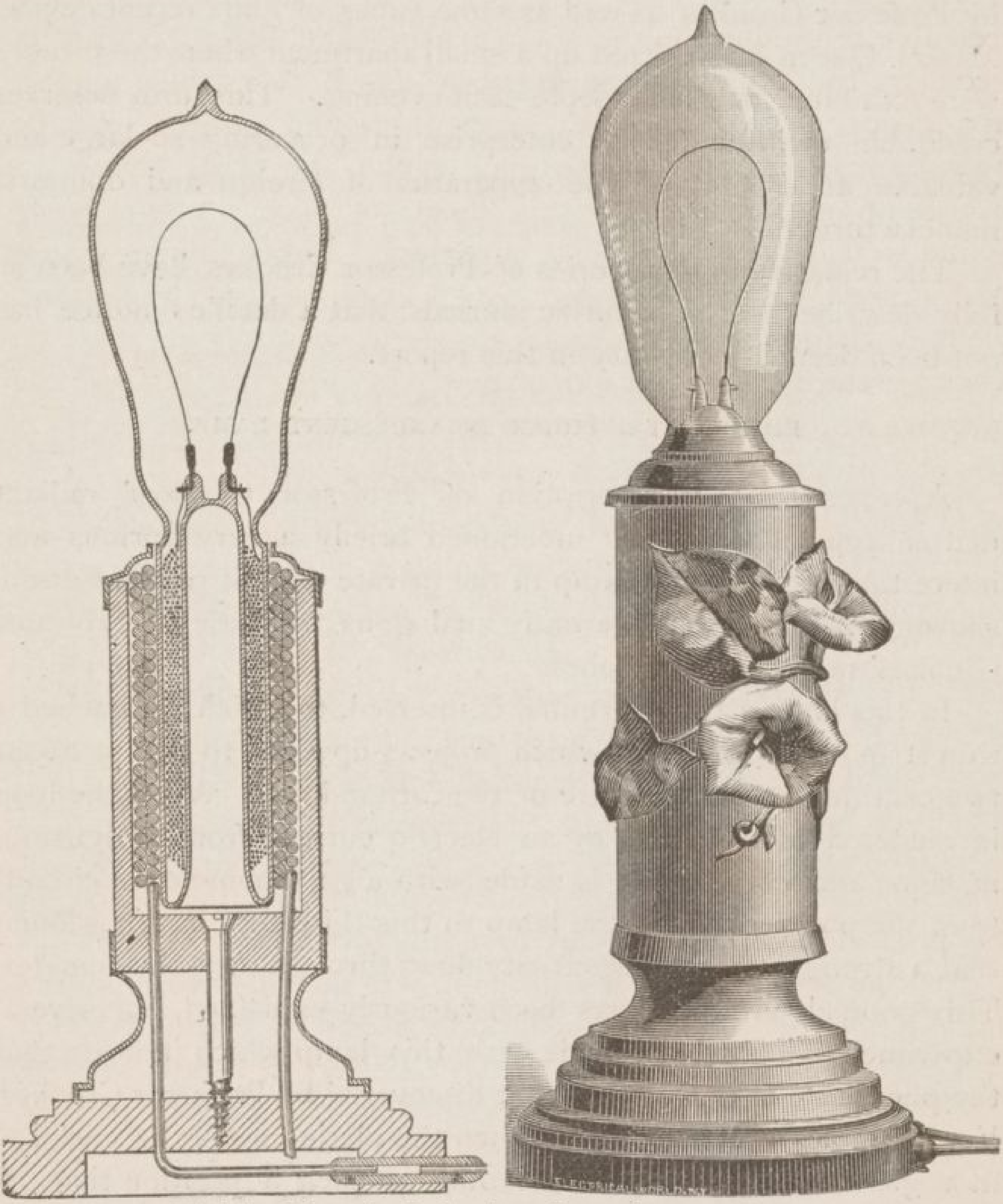
Apropos to this description of Professor Crookes' radiant matter apparatus may be mentioned briefly a very curious and interesting incandescent lamp in the private exhibit of Mr. Edison, showing phenomena apparently analogous to those of Professor Crookes' radiant matter tubes.

In this lamp a third terminal is inserted, to which is attached a thin strip of platinum foil, which projects upwards to within about two centimetres of the centre of the carbon loop. When the loop is rendered incandescent by an electric current from a dynamo-machine and a connection is made (with a galvanometer in circuit) from the positive pole of the lamp to this third terminal, it is found that a strong current of electricity flows through the galvanometer. This anomalous action has been variously explained, but several experiments have been made with this lamp which indicate that the phenomenon is similar to that discovered by Professor Crookes. For example, it is found that when the platinum pole is enclosed in a glass tube sealed into the bulb in such a position that the platinum foil is in a direct line with the carbon, the phenomenon appears as before, but when the tube is bent at right angles, no such effect takes place.

Several other interesting experiments with this lamp were described, but not shown, and the effects observed are worthy of more careful study than the committee was able to give at the time.

DIEHL'S ELECTRIC–INDUCTION INCANDESCENT LAMP.

In the exhibit of the Singer Sewing Machine Company, the committee found several ingenious forms of incandescent lamps in



Diehl's Electric Induction Incandescent Lamps.

which no terminal wires penetrate the glass, the whole action depending upon induction through the glass.

These lamps were devised by Mr. Philip Diehl, of Elizabethport, N. J., and require an intermittent current to develop the inductive action; the current from the dynamo does not enter the lamp, but passes into a coil of wire which surrounds a glass tube, forming the base of the bulb. Inside the tube is a second coil, whose terminals are connected with the carbon filament, and when the intermittent current is passed through the outer coil, a secondary current is induced in the inner coil, which heats up the carbon to the point of incandescence.

The inventor stated that the best form of lamp which he had been able to produce on the induction principle, has an interior or secondary coil of only four layers of No. 30 B. & S. gauge, uncovered copper wire. The first layer is wound directly on the inwardly reaching tube of the glass globe, the other layers are insulated from each other by thin sheets of mica, the wire being wound so that there is no point of contact. Naked copper wire is used in preference to insulated wire coil to facilitate the subsequent evacuation of the bulb, as any form of insulating material tends to retard the perfect exhaustion. In order to increase the inductive action, bundles of iron wire are inserted in the centre of the tube, around which the secondary coil is wound.

The weight of copper wire used for the interior coil is one-third of an ounce.

The exterior coil consists of but two layers of naked copper wire, No. 16 B. & S. gauge. These layers are insulated from each other with asbestos paper, the weight of wire being three and one-half ounces.

The exhibitor claimed that the largest lamp shown would give a light of about forty candles, and stated that he had run five of those lamps with an expenditure of one horse-power, and that he was confident that still better results could be obtained when the true proportions of the coils are found by further experiments.

Another style of incandescent lamp was shown, having interior and exterior condensers, intended to be used with currents of very high electro-motive force, as in the Geissler, or Crookes tubes, except that there are no terminal wires liable to become heated, and so destroy the seal. The condensers form a sort of accumulator, so that when the current of electricity is momentarily interrupted, the steadiness of the light will not be affected.

After some difficulty, owing to the absence of the inventor and the want of a suitable dynamo for this purpose, the committee succeeded in operating two of the lamps, by introducing a circuit breaker, but it was not possible to make any tests, either of the candle-power of the light or the power consumed, but the committee is able to state that the carbon filaments glowed with a steady and fairly brilliant light; and while no opinion is expressed as to the practicability of this form of lamp, it was thought that it possessed sufficient novelty and interest to warrant a brief notice in this report.

If there are any other exhibits which the committee has omitted to mention, it must be attributed to the neglect of the exhibitors to notify the Chairman of the Board of Examiners of the objects which they desired to have reported upon, and to the want, during the earlier part of the Exhibition, of an official catalogue.

All of which is respectfully submitted by

JOHN B. DE MOTTE, *Chairman*,
A. E. OUTERBRIDGE, JR., *Secretary*.
Committee on Section XIII, Class 2.

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